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AN ANALYSIS OF GENERATION MEANS FOR SEED YIELD AND ITS COMPONENTS IN LINSEED

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ABSTRACT

Five generations (P_1 P_2, F_1, F_2 and F_3) of seventeen linseed crosses, were raised in randomized block design with three replications. The means of the five generations recorded for oil content, seed yield and its contributing traits, were subjected to C-scaling test as suggested by Mather (1949) and five-parameter model of Hayman (1958) to detect epistasis and estimates of (m), (d), (h), (i) and (1) parameters. There was evidence of epistasis for all the eight traits. Additive gene effect along with epistasis predominantly governed the expression of oil content while non-additive gene effect with epistasis was predominant in number of branches plant^{-1}, number of capsules plant^{-1} and seed yield plant^{-1}. Days to maturity, number of seeds capsule^{-1}, seed index and harvest index were under the control of both additive and non-additive gene effects together with non-allelic interactions viz., additive x additive and dominance x dominance. A predominance of complementary type of epitasis was observed for number of capsules plant^{-1}, seed yield plant^{-1}, harvest index and oil content followed duplicate type.

Key words : Epitasis, gene effects, generation means, linseed, oil content, yield components.

Linseed is an important oilseed crop grown primarily for its quick drying oil widely used in paint and varnish industries. For proper understanding of inheritance of various quantitative traits, generation mean analysis can be useful for crop improvement in this crop.

MATERIALS AND METHODS

The experimental material comprised seventeen crosses of R7 as a tester with seventeen divergent lines of linseed. R7 is a widely adapted cultivar with desirable agronomical characters. Five generations namely, P_1, P_2, F_1, F_2 and F_3 of each of these seventeen crosses were raised in a randomized block design with three replications in 3m long rows with row-to-row distance of 30 cm and plant to-plant 10 cm during *rabi* 2000-01. Each parent and F_1 generation were represented by two rows and F_2 and F_3 generations by 20 rows. All the standard agronomical practices were followed to raise the crop. The data were recorded on five randomly selected competitive plants in each row for eight metric traits: days to maturity, number of branches plant^{-1}, number of capsules plant^{-1}, number of seeds capsule^{-1}, seed index (g), seed yield plant^{-1} (g), oil content (%) and harvest index (%). The data were subjected to the C-scaling test as suggested by Mather (1949) to detect the presence of epistasis and then five-parameter model of Hayman (1958) was fitted to the data to obtain estimates of m, (d), (h) and (1) parameters.

RESULTS AND DISCUSSION

The values of C-scaling test and the estimates of m, d, h, i and I parameters for eight metric traits in seventeen crosses are given in Table 1. The C-scaling test values were significant for days to maturity in all the crosses except RLC 2/R 7 and RLS 1/R 7, indicating inadequacy of additive-dominance model i.e., epistasis was present in most of the crosses. The fitting of the five parameter model to the data indicated involvement of all the three kinds of gene effects (additive, dominance and epistasis) in these crosses. The inheritance of maturity was under the control of epistasis in majority of the crosses. Regarding the classification of epistasis, which largely depends on the signs of (h) and (l), a predominance of duplicate type of epistasis was observed in majority of the crosses.

Both additive and dominant gene effects governed the expression of days to maturity (Table 1). Similar results have also been reported earlier by Tak (1989) and Mahto and Rahman (1998). Whereas, Bhateria *et al.* (2001), Rao *et al.* (2001) and Tiwari *et al.* (2004) reported the role dominant gene effect in the inheritance of this trait. Among the interaction components, the dominance x dominance and additive x additive epistasis were equally important in majority of the crosses.

Inheritance of number of branches plant^{-1} was found to be governed by epistasis in all the crosses except R17 / R7 and EC 1419/R7. Majority of the crosses followed duplicate type of epistasis. The dominance x dominance epistasis was more important than additive x additive component in these cases. Different crosses exhibited varying types of gene effects in addition to presence of epistasis. Dominance effects were of greater importance than their corresponding additive effects. Role of dominant gene effect in the expression of number of branches plant^{-1} was also reported by Mahto and Rahman (1998), Kumar *et al.* (2000), Rao *et al.* (2001) and Tiwari *et al.* (2004).

Inheritance of number of capsules plant^{-1} was controlled by epistasis in all crosses except RLC 2 / R 7. Majority of the crosses followed duplicate type of epistasis. The dominance x dominance epistasis was more important than additive x additive component. Different crosses exhibited varying types of gene effects. Dominance effect was relatively more important for number of capsules plant^{-1}. The results are in agreement with findings of Mahto and Rahman (1998), Kumar *et al.* (2000), Bhateria *et al.* (2001), Rao *et al.* (2001) and Tiwari *et al.* (2004).

Inheritance of number of seeds capsule^{-1} was governed by epistasis in all the crosses except NP 447 / R 7, RLC 2/ R 7 and SPS 2310 / R 7. Majority of crosses followed complementary type of epistasis. The dominance x dominance epistasis was relatively more important than additive x additive component. Different crosses exhibited varying types of gene effects in addition to presence of epistasis. Both additive and dominance gene effects were important in the inheritance of the number of seeds capsule^{-1}. However, the role of non-additive gene action in the expression of this trait reported by Mahto and Rahman (1998), Kumar *et al.* (2000), Bhateria *et al.* (2001), Rao *et al.* (2001) and Tiwari *et al.* (2004). The negative value of 'h' observed for number of seeds capsule^{-1} in majority of crosses, indicated that alleles responsible for less number of seeds were dominant over the alleles controlling more number of seeds.

Seed index being an important yield component was under control of epistasis in majority of crosses. Different crosses followed varying types of epistasis. Six crosses registered complementary type of epistasis *viz.*, RLC 2/ R 7, SPS 2310 / R 7, R 17/ R 7, EC 1419/R 7, EC 1486/R 7 and NP 29/R 7 while, other crosses like RLC 5/ R7, RLC 3/ R 7, NP 420/R 7 and IPI 8/R 7 followed duplicate type of epistasis. On the other hand, adequacy of additive-dominance model was observed in NP 447/ R7, RLC 7/ R7, EC 21741/R 7, RLC 1/R 7, RLC 4/R 7, No. 12/R 7 and R 552/R 7. Among the interaction components, both additive x additive and dominance x dominance components were involved in the inheritance of seed index. Both additive and dominance gene effects were involved in majority of crosses. The results were also supported by Tiwari *et al.* (2004). Whereas, Mahto and Rahman (1998) reported the role of additive gene effect in the inheritance of this trait. While, role of non-additive gene effect was reported by Bhateria *et al.* (2001) and Rao *et al.* (2001).

Inheritance of yield plant^{-1} was controlled by epistasis. Majority of crosses followed duplicate type of epistasis. On the other hand, adequacy of additive-dominance model was registered by crosses NP 447/R 7, RLC 5/ R 7, RLC 2/ R 7, SPS 2310/R 7, EC 1419/R 7, R 552/ R7 and IPI 8/R7. Among the interaction components, both additive x additive and dominant x dominant epistasis were equally important. The dominant gene effect was relatively more important than additive gene

Table 1. Estimates of gene effects, types of epistasis and value of C-scaling for eight metric traits in seventeen linseed crosses

Characters		Cross	Gene effects					C-scale test	Types of epistasis
			m	d	h	1	i		
Days to maturity	1	NP 447/R 7	101.13**	1.53**	-4.40*	30.40**	-5.73**	301.75**	D
	2	RLC 5/R 7	103.16**	-2.67**	-35.66	238.51**	-83.61**	327.39**	D
	3	RLC 7/R 7	103.04**	0.50	2.11	-32.43**	10.15**	408.38**	D
	4	ECL 21741/R 7	105.71**	4.90**	10.25**	-62.83**	31.62**	1657.85**	D
	5	RLC 3/R 7	104.62**	0.03	4.12*	38.19**	-8.86**	854.58**	C
	6	RLC 2/R 7	104.69**	2.80**	4.41*	17.28	2.40	2.78	-
	7	RLC 1/R 7	104.48**	-0.53	2.53	-11.95	2.68	367.81	-
	8	RLC 4/R 7	102.80**	1.57*	-5.47**	68.80**	-15.10**	712.92**	D
	9	SPS 2310/R 7	101.78**	0.07	-5.09	14.83**	-6.50**	857.78**	D
	10	R 17/R 7	103.26**	0.87	1.69	28.80**	-5.38*	536.15**	C
	11	EC 1419/R 7	102.45**	-2.37**	-3.09	16.43**	-13.80**	15.18**	D
	12	No. 12/R 7	99.92**	-1.03	-1.43	51.20**	-15.59**	974.02**	D
	13	R 552/R 7	101.56**	-0.33	-1.68	37.77*	-8.57**	972.12**	D
	14	NP 420/R 7	99.78**	0.07	-3.71	41.73**	-10.66**	935.38**	D
	15	IPI 8/R 7	104.89**	0.07	-1.77	-33.71**	7.66**	883.94**	C
	16	EC 1486/R 7	103.47**	1.40	3.41	30.72**	-4.24	697.47**	C
	17	NP 29/R 7	104.80**	2.80**	2.80	-27.41**	13.47**	1228.87**	D
Number of branches plant^{-1}	1	NP 447/R 7	21.60**	-1.93	15.85**	-102.33**	23.70**	38.60**	D
	2	RLC 5/R 7	17.54**	1.90**	6.51	60.16**	-12.53**	70.71**	C
	3	RLC 7/R 7	29.38**	3.63**	38.32**	-210.45**	-70.36**	97.31**	D
	4	ECL 21741/R 7	20.71**	-0.71	11.81**	-92.16**	18.53**	31.26**	D
	5	RLC 3/R 7	20.85**	2.27*	15.25**	47.15**	-6.21	51.82*	C
	6	RLC 2/R 7	22.13**	-0.73	16.66**	-66.35**	15.12**	888.93**	D
	7	RLC 1/R 7	18.71**	-0.63	14.27**	-102.94**	27.19**	90.56**	D
	8	RLC 4/R 7	20.94**	0.78	15.03**	-65.39**	20.03**	60.47**	D
	9	SPS 2310/R 7	16.67**	-1.10	9.55**	37.12**	-10.75	32.85*	C
	10	R 17/R 7	16.00**	3.03**	7.70**	16.22	-7.44	32.65	-
	11	EC 1419/R 7	17.89**	0.23	6.98*	9.07	-2.30	857.29	-
	12	No. 12/R 7	22.09**	-1.00	14.70**	110.83**	25.57**	30.86**	D
	13	R 552/R 7	16.60**	3.10**	7.32**	-31.90**	14.80**	28.31**	D
	14	NP 420/R 7	22.76**	1.10**	16.89	-147.20**	40.73**	74.07**	D
	15	IPI 8/R 7	21.72**	0.74	16.09**	-71.47**	18.87**	46.97**	D

	16	EC 1486/R 7	18.95**	0.07	5.03	-36.80**	7.30	33.49*	D
	17	NP 29/R 7	33.60**	4.57**	35.61**	-298.46**	84.85**	401.36**	D
Number of capsules plant^{-1}	1	NP 447/R 7	63.85**	-6.83**	61.14**	-396.16**	94.34	411.97*	D
	2	RLC 5/R 7	68.18**	6.70**	53.44**	99.63**	-10.53	863.70**	C
	3	RLC 7/ R 7	68.04**	3.10	42.97	-200.65	6729**	6254.24**	D
	4	ECL 21741/R 7	62.58**	-5.20**	60.63**	-333.87**	71.40**	118.87**	D
	5	RLC 3/R 7	62.25**	5.20	36.59**	146.35**	-27.40	125.02*	C
	6	RLC 2/R 7	59.20**	0.73	51.46**	-35.95	10.99	348.15	-
	7	RLC 1/R 7	36.11**	6.74*	-12.36	412.80**	-86.43**	149.47**	D
	8	RLC 4/R 7	59.87**	3.90*	17.27	147.63**	-30.65*	23.26**	C
	9	SPS 2310/R 7	60.66**	-7.33*	39.28**	-151.66**	26.22	808.48*	D
	10	R 17/R7	62.78**	-4.33	54.44**	-175.15**	45.63**	309.31**	D
	11	EC 1419/R 7	58.85**	-9.74**	59.30**	322.14**	-96.60**	84.78**	C
	12	No. 12/ R 7	77.18**	-6.30*	64.27**	-444.54**	91.86**	1594.42**	D
	13	R 552/R 7	59.14**	10.84**	23.47**	-131.20**	50.24**	10422.75**	D
	14	NP 420/R 7	75.09**	5.17	98.41**	-467.53**	152.03**	6342.03**	D
	15	IPI 8/R 7	56.40**	-2.87	28.40**	-130.35**	25.39*	3009.11*	D
	16	EC 1486/R 7	57.76**	-4.84	22.51*	-100.91**	13.76	122.80*	D
	17	NP 29/R 7	88.87**	7.44	63.10**	-695.15**	178.15**	792.76**	D
Number of seeds capsule^{-1}	1	NP 447/R 7	6.26**	-0.16	-0.38	-3.57	1.16	267.04	-
	2	RLC 5/R 7	7.00**	0.76*	-0.12	-5.61**	2.63**	283.96**	C
	3	RLC 7/R 7	7.26**	1.05**	-1.29	-8.20**	3.76**	45.86**	C
	4	ECL 21741/R 7	6.22**	-0.70**	-1.28*	-7.87**	-0.11	9.04*	C
	5	RLC 3/R 7	6.14**	0.02	-3.83	22.39	-7.03**	82.76*	D
	6	RLC 2/R 7	6.52**	-0.50**	-0.11	-	-	2.10	-
	7	RLC 1/R 7	6.69**	-0.32	-1.62**	-.6.23**	0.36	6.88*	C
	8	RLC 4/R 7	6.88**	0.27	-1.26*	-1.84	0.98	112.24*	C
	9	SPS 2310//R 7	6.96**	0.18	-0.39**	-1.68	0.76	8.89	-
	10	R 17/R 7	6.41**	-0.69**	-2.03**	-13.84**	0.91	46.88*	C
	11	EC 1419/R 7	6.23**	-0.20	-2.04**	-10.50**	0.87	28.69*	C
	12	No. 12/R 7	6.92**	0.30	-0.95	-27.56**	6.73**	93.75*	C
	13	R 552/R 7	6.43**	-0.16	0.14	5.72**	-0.95	6.41*	C
	14	NP 420/R 7	6.54**	-0.44**	0.35	-24.57**	4.70*	42.71**	D
	15	IPI 8/R 7	6.12**	-0.20	-3.34**	-7.73**	-0.35	44.37*	C
	16	EC 1486/R 7	6.78**	0.02	0.88	-28.53**	6.95**	57.86**	C
	17	NP 29/R 7	6.75**	-0.36	0.09	-29.07**	6.16**	62.35**	D

Seed index	1	NP 447/R 7	8.59**	0.26	-0.14	-0.55	-0.27	15.11	-
	2	RLC 5/R 7	7.40**	-1.25**	3.46*	-16.09**	2.62**	35.02**	D
	3	RLC 7/R 7	6.43**	-0.93**	1.26**	-	-	0.88	-
	4	EC 21741/R 7	7.32**	-0.79**	0.34	-	-	3.04	-
	5	RLC 3/R 7	8.25**	0.39	2.48**	-11.32**	4.09**	7.15**	D
	6	RLC 2/R 7	8.09**	0.66**	1.42*	12.14**	1.23**	14.89**	C
	7	RLC 1/R 7	7.51**	-0.02	0.70	-	-	3.41	-
	8	RLC 4/R 7	7.54**	-2.04	1.20**	-	-	0.69	-
	9	SPS 2310/R 7	8.15**	-0.31*	-0.87	-17.52**	2.64	21.10*	C
	10	R 17/R 7	8.77**	0.46**	2.77**	0.62	1.43*	7.37*	C
	11	EC 1419/R 7	7.23**	-0.57**	0.67	10.53**	-3.76**	8.04*	C
	12	No. 12 /R 7	6.39**	-1.73**	2.14**	-	-	-3.67	-
	13	R 552/R 7	7.45**	-0.01	0.53	-	-	-3.37	-
	14	NP 420/R 7	7.54**	-0.80**	3.20**	-11.10**	2.24**	25.14**	D
	15	IPI 8/R 7	8.76**	0.29**	3.94**	-25.63**	7.66**	24.90**	D
	16	EC 1486/R 7	6.52**	-1.16**	0.59	13.98**	-6.27**	11.88**	C
	17	NP 29/R 7	7.11**	0.05	0.81*	6.82**	-1.17*	8.71**	C
Seed yield plant^{-1}	1	NP 447/R 7	3.26**	-0.33*	4.49**	0.57	0.44	27.42	-
	2	RLC 5/R 7	1.95**	0.41	2.74*	-	-	1.30	-
	3	RLC 7/R 7	3.93**	0.07	4.42**	-12.08**	3.87**	6.85**	D
	4	ECL 21741/R 7	3.11**	-0.70**	1.13	-5.23*	-1.07	6.31**	D
	5	RLC 3/R 7	3.18**	0.27	3.19**	12.97**	-1.99*	7.47**	C
	6	RLC 2/R 7	3.35**	0.41*	4.53**	1.03	1.56	11.45	-
	7	RLC 1/R 7	2.16**	0.08	0.19	19.31**	-4.73**	8.31**	C
	8	RLC 4/R 7	4.16**	0.05	4.80**	-23.70**	6.66*	10.00**	D
	9	SPS 2310/R 7	2.06**	-0.41	2.04**	-	-	2.12	-
	10	R 17/R 7	3.40**	-0.50**	3.12**	-22.75**	5.08**	15.30**	D
	11	EC 1419/R 7	2.01**	-1.20**	1.15**	-	-	-2.04	-
	12	No.12/R 7	3.34**	-0.62**	2.96**	-22.73**	4.12**	10.44**	D
	13	R 552/R 7	2.18**	0.41*	1.83**	-	-	-2.96	-
	14	NP 420/R 7	3.53**	-0.05	-32.56**	201.03**	-68.14**	269.49**	D
	15	IPI 8/R 7	1.93**	-0.21	1.36**	-	-	1.34	-
	16	EC 1486/R 7	2.99**	-1.17**	1.12	-16.92**	2.08*	6.16**	D
	17	NP 29/R 7	3.88**	0.32	2.05	-21.62**	5.37**	11.43**	D
Harvest index	1	NP 447/R 7	40.36**	1.34	4.80	-63.37	-15.23**	8.00*	D
	2	RLC 5/R 7	34.89**	-3.95**	6.17**	-	-	4.82	-

	3	RLC 7/R 7	3.78**	1.95	9.64**	-	-	4.37	-
	4	ECL 21741/R 7	39.26**	-13.60**	6.62	-203.40**	18.37**	40.30**	D
	5	RLC 3/R 7	40.28**	16.64**	-6.28	101.98**	22.64**	56.81**	D
	6	RLC 2/R 7	37.29**	2.13	4.54**	-	-	3.84	-
	7	RLC 1/R 7	38.00**	-0.62	-20.92**	161.57**	-50.40**	10.40**	D
	8	RLC 4/R 7	43.28**	0.84	2.84	-60.60**	10.74**	13.52**	D
	9	SPS 2310/R7	42.21**	-4.99	1.99	-51.87**	4.89	14.16*	D
	10	R 17/ R 7	40.10**	-2.08*	1.41	41.63**	5.50	6.00*	C
	11	EC 1419/ R 7	37.24**	-5.20	-8.24	92.84**	-38.64**	8.50**	D
	12	No. 12/R 7	39.00**	-4.44**	-1.03	-17.40	-8.95*	10.97*	C
	13	R 552/R 7	42.23**	1.65	7.09	40.88	-5.73	8.36	-
	14	NP 420/R 7	38.22**	1.09	15.37**	-24.99	19.41**	27.31*	D
	15	IPI 8/R 7	35.31**	-1.76	-1.29**	-	-	5.35	-
	16	EC 1486/R 7	38.55**	-8.71**	-1.32	-83.32**	12.16	27.02*	C
	17	NP 29/ R 7	33.99**	2.47	-9.60	19.32	5.04	9.02	-
Oil Content	1	NP 447/R 7	35.80**	-0.94	-3.29*	-20.27**	-0.75	18.50*	C
	2	RLC 5/ R 7	35.60**	-0.77	2.02	-23.74**	5.07*	244.38**	D
	3	RLC 7/R 7	35.82**	0.22	0.82	4.43	-0.59	43.79	-
	4	ECL 21741/R 7	34.00**	-1.94*	-2.91	19.47	-11.73	55.79	-
	5	RLC 3/R 7	36.68**	1.17	1.38	-51.20	16.02	73.90	-
	6	RLC 2/R 7	37.28**	0.99*	-0.76	-6.40	3.64	33.01	-
	7	RLC 1/R 7	35.62**	-1.24*	3.28	1.78	-5.20**	16.09*	C
	8	RLC 4/R 7	336.17**	-1.08**	1.45	-6.67	-0.95	3.22	-
	9	SPS 2310/R 7	37.01**	0.63	-2.14	-6.94	-0.72	30.94	-
	10	R 17/R 7	37.22**	0.55	-1.74	2.14	-1.32	68.70	-
	11	EC 1419/R 7	34.45**	0.31	-1.96	17.07**	-3.19	10.76*	D
	12	No. 12/R 7	36.49**	-0.18	0.63	-24.45**	4.29**	19.98**	D
	13	R 552/R 7	34.39**	0.11	-2.65	26.40**	-8.34**	19.45**	D
	14	NP 420/R 7	36.36**	-0.31	2.02	-51.99**	11.92**	17.41**	D
	15	IPI 8/R 7	36.07**	0.99*	3.83*	-21.87**	7.32**	55.97**	D
	16	EC 1486/R 7	34.85**	1.87**	-4.74**	-9.34**	2.99	41.19*	C
	17	NP 29/R 7	35.49**	-0.10	4.09	-43.20**	11.96**	17.80**	D

*P≤0.05 and** P≤ 0.01; C=complementary, D=Duplicate effect in the inheritance of seed yield plant^{-1}. The importance of non-additive gene action has also been reported for yield and its components by Neelam *et al.* (1981), Singh *et al.* (1983), Mahto and Rahman (1998), Bhateria *et al.* (2001) and Tiwari *et al.* (2004). As this type of gene action is non-fixable, hybrid vigour may be useful for higher production. However, chance of exploiting hybrid vigour through hybrid varieties in linseed at present are bleak due to its autogamous nature. Under such situation, biparental mating followed by recurrent selection would be the best approach in linseed improvement.

The presence of both additive and non-additive type of gene effect was observed for inheritance of harvest index. While, Mahto and Rahman (1998) and Bhateria *et al.* (2001) reported predominant role of dominant gene effect in the inheritance of this trait. Similarly, both epistatic components of variance were involved in the inheritance of the trait. Majority of the crosses followed duplicate type of epistasis. On the other hand, absence of epistasis was involved in six crosses *viz.*, RLC 5/ R 7, RLC 7/ R 7, RLC 2/ R 7, R 552/ R 7, IPI 8/R 7 and NP 29/ R7. Bhateria *et al.* (2001) reported prevailing role of non-additive gene action for inheritance of harvest index.

Inheritance of oil content was under control of epistasis in majority of cases. Most of the crosses followed duplicate type of epistasis. Dominance x dominance type of interaction component was more important than additive x additive type. On the other hand, absence of epistasis was involved in seven crosses *viz.*, RLC 7/ R 7, EC 21741/R 7, RLC 3/ R 7, RLC 2/ R 7, RLC 4/ R 7, SPS 2310/R 7 and R 17/R 7. Additive gene effect was relatively more important than dominance type. The isolation of superior lines may be difficult in small populations of heterotic crosses in which the number of segregation loci with additive gene effect is relatively large. In these crosses, it would be necessary to adopt the biparental crosses approach for accumulation of favorable and additive gene effect. These results are in agreement with Rao *et al.* (2001), Daucet (1978), Rao and singh (1983), Tak (1996) and Foster *et al.* (1998). However, predominant role of dominant gene effect in controlling the trait was reported by Mahto and Rahman (1998) and Tiwari *et al.* (2004).

Additive gene effect along with epistasis predominantly governed the expression of oil content while non-additive gene effect with epistasis was predominant in number of branches plant^{-1}, number of capsules plant^{-1} and seed yield plant^{-1}. Days to maturity, number of seeds capsule^{-1}, seed index and harvest index were under the control of both additive and non-additive gene effects together with both types of non-allelic interactions *viz.*, additive x additive and dominance x dominance. Under such circumstances, it is suggested that biparental mating design III by Comstock and Robinson (1948) may be used to identify promising genotypes of linseed.

The significant contribution of both additive x additive (i) and dominance x dominance (1) type of epistasis for days to maturity, seed index, seed yield and harvest index suggests that former type should not be ignored while, predicting the recombinants extractable from segregating generations, while later type should be used for enhancing the chance of exploiting hybrid vigour through hybrid varieties in linseed. A predominance of complementary type of epistasis was observed for number of seeds capsule^{-1} and seed index. The presence of complementary type epistasis would expose the detectable genetic variance in the population and the probability of obtaining recombinants.

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RESPONSE OF WHITE CLOVER GENOTYPES TO PHOSPHORUS AND RHIZOBIUM

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ABSTRACT

Seven genotypes of while clover (*Trifolium repens* L.) were compared for their response to phoshorus and rhizobium treatment. White clover being an out crossing species exhibit lot of variability both within and between populations. These seven genotypes also differed significantly in their morphology. These genotypes were treated with four doses of phosphorus (0, 13, 27 and mg P/kg soil) and two of rhizobium. The genotypes differed significantly in their response to these treatments in terms of morphology and biomass yield. Genotypes L100, L99, L27 and L10 yielded more biomass at low P level.

Key words : White clover, phosphorus, rhizobium, biomass.

White clover (*Trifolium repens* L.) is a predominant forage legume of temperate pastures. It improves forage quality and provides up to 400 kg N/ha in grazed swards annually through N-fixation (Crush, 1987). It also improves the nutritive value of the herbage and therefore, there is increase in milk yield and body weight of animals which are fed increasing proportion of white clover (Thomson, 1984). Because of its stoloniferous growth and phenotypic plasticity, it is an ideal companion legume in most grass swards (Woodfield and Caradus, 1994). As an outcrossing species, white clover is genetically variable. Variation among plants in single field has been studied by Harper (1977) and Burdon (1980). The later study reported significant variation for twenty-two characters among 50 plants. Caradus *et al.* (1989) also reported a lot of genetic variability both within and between white clover populations for most traits of interest. Sareen (2003) also reported significant variability between white clover populations collected from mid hill Himalayas. Many workers have investigated the responses of white clover to phosphorus applied in mixed pastures (Wolfe and Lazenby, 1973; Rangeley and Bolton, 1986; Schulls, 2002) or in monocultures (Rangeley and Newbould, 1985; Hart and Collier, 1994; Bailey and Laidlaw, 1998), but there are no reports on differential response of white clover genotypes to phosphorus. Therefore, the present study was undertaken to compare the response of white clover genotypes. Out of ninety-five populations collected from mid hill Himalayas, seven were selected to study their response to phosphorus and rhizobium application.

MATERIALS AND METHODS

Of ninety-five population collected from mid hill Himalayas, six genotypes were selected on the basis of their performance at IGFRI Regional Research Centre farm for three consecutive years. The soil was clay loam with 5.9 - 6.5 pH, 10.75 kg P/ha, 11.25 kg K_2O/ha and 0.59%C. These genotypes were high yielders and persistent under these conditions. The seventh genotype L100 is the wild type growing abundantly in the farm area. Forty stolons each with four growing tips were selected from populations of these genotypes. These stolons were transplanted in pots containing potting mixture (soil, sand and organic manure). Four treatments of phosphorus 0, 13, 27 and 40 mg/kg soil were applied. Rhizobium treatment was given to half of the stolons. In all, for the present study, seven genotypes, four treatments of phosphorus and two of rhizobium i.e., total of

Table 1. Data on morphology of selected genotypes

Parameter	Genotype						
	L10	L13	L19	L23	L27	L99	L100
Plant ht. (cm)	4.73	4.37	5.00	4.50	4.40	7.83	2.67
Leaf count	35.33	49.67	89.00	46.00	216.67	41.67	31.67
Mid leaflet (cm)	0.57	0.57	0.57	0.43	0.63	0.70	0.47
Petiole length (cm)	2.57	2.83	4.13	3.13	3.63	8.53	2.53
Stolon size (cm)	6.60	5.00	8.93	7.43	9.93	13.67	8.03
Nodes/Stolon	5.33	4.33	6.67	6.00	9.33	8.33	7.00
Internode length	1.27	0.93	1.30	1.17	0.90	1.63	1.07
No. of growing points	6.67	7.33	12.33	5.00	16.33	5.67	3.67
Fresh biomass/plant (g)	2.24	2.85	2.45	2.43	2.54	1.68	3.41
Dry biomass/plant (g)	1.69	2.22	2.16	1.77	1.90	0.43	2.68

fifty-six treatments were used. Five replicates for each treatment were used.

Five plants from each genotype were marked at the time of transplantation and data on their morphology was recorded. The biomass of these was also recorded. All these stolons were allowed to grow in pots and data on the morphology and yield related parameters were recorded after every 45 days. For mid leaflet width, stolon length, nodes/stolon and internode size, average from three readings was obtained. Data on biomass is the total herbage collected in year.

All the data was analyzed statistically and considering the experiment as complete randomized block design.

RESULTS AND DISCUSSION

Comparison of genotypes

The data on morphology of the selected genotypes is given in Table 1. All the genotypes vary in their morphological details. The leaf size varied from 0.43 to 0.7 cm, stolon 5.0 to 13.7 cm long, 4 to 9 nodes and 0.9 to 1.6 cm long internodes. The number of growing points varied from 5 to 16. The fresh biomass per plant varied from 1.7 to 3.4 cm.

Response to phosphorus treatments

The genotypes did not respond similarly to phosphorus treatments. Some genotypes enhanced the growth at low doses while some registered decline. Plant height increased at lower concentrations in genotypes L19, L10 and L27, decreased in genotypes L13, L99 and L100 but was unaltered in genotype L23. Leaf size increased at higher dose in genotypes L10, L13, L19, L27 and L99 but petiole length increased in all genotypes at low P treatment. Stolen length increased at low P dose in L23 and L99. The internode size decreased at low dose in L13, L23, L99 and L100, but it increased in L10 and L19 and decreased in L27 with all doses. The growing points increased at low dose in genotypes L10,, L13 and L19 and all doses in L23 and L100. Heads/plant and florets/head increased at low phosphorus dose in L10, L19 and L23 but seed/floret decreased with all treatments in all genotypes except L99 where it decreased at low dose only.

Response to rhizobium

With rhizobium treatment also, the treatments responded differently. The plant height increased with rhizobium treatment in genotype L99. The mid leaf size increased in genotypes L10 and L13, petiole length in L100, stolon length in L10 and L23, but nodes/stolon decreased in L100 and internode in L13 with the rhizobium treatment. The number of growing points decreased in L13 and L23. The reproductive traits decreased mostly in rhizobium treated plants except seed/floret, which increased slightly in genotypes L19 and L27.

While evaluating ninety-five collections of white clover, groups were made on the basis of plant height, leaf size, cyanogenesis and seed and herbage yield. Among these groups, the better performing six genotypes were identified for the present study. The data on morphology of these genotypes revealed presence of

Table 2. Significance of genotype x P level interaction and genotype x rhizobium interaction as determined by analysis of variances

Plant character	Genotype (G)	Phosphorus (P)	Rhizobium (R)	G x P	G x R	G x P x R
Plant height	*	ns	ns	ns	ns	*
Mid leaflet	**	**	ns	ns	ns	**
Petiole length	**	ns	ns	**	**	**
Stolon size	**	**	ns	**	**	ns
Nodes/stolon	**	ns	ns	**	**	*
Internode length	**	ns	ns	ns	ns	ns
Growing points	**	**	ns	**	**	ns
Heads/plant	**	ns	**	ns	**	ns
Florets/head	**	ns	ns	*	ns	ns
Seed/floret	**	ns	ns	ns	ns	ns
Biomass	**	ns	ns	**	ns	**

significant variability between them for all the parameters except internode size, florets/head and seed/floret. White clover is an open pollinated, therefore it exhibits enormous variation within and between populations (Sareen *et al.* 1998; Sareen 2003). The intra population variation present in white clover has also been investigated by number of workers like Burdon (1980), Caradus *et al.* (1989), Caradus and Woodfield (1990), Annicchiarico (1993) and Annicchiarico and Piano (1995).

Many workers have investigated the responses of white clover to superphosphate applied to P deficient pasture soils. Wolfe and Lazenby (1973) followed the effects of four rates of super phosphate on development of white clover with grass species and found that initially white clover showed a linear response but later grasses exceeded. Schills (2002) reported that phosphorus application did not increase clover yield and had a negative effect on clover proportions in mixed swards. However, only few workers had investigated the effect of phosphorus on white clover growth in monocultures. Adverse effects of P deficiency on clover leaf development and stolon branching at establishment has been reported by Rangeley and Newbould (1985); Rangeley and Bolton (1986); Hart and Collier (1994) and Bailey and Laidlaw (1998). No study has been conducted to compare different genotypes of white clover for their response to phosphorus application. During the present study, the genotypes did not respond in the similar manner to phosphorus application. The effect of phosphorus was significant for mid leaf size, stolon length and growing points (Table 2). However, interaction between genotype was significant for petiole length, stolon size, nodes/stolon branch, growing points, florets/head and biomass. Although with rhizobium treatment also these genotypes responded differently, the effect of rhizobium treatment was significant for heads/plant only. Howerver, interaction between rhizobium and genotype was significant for petiole length, stolon size, nodes/stolon branch, growing points and heads/plant. The interaction between three components namely, genotype, phosphorus and rhizobium was significant for plant height, mid leaf size, petiole length, nodes/stolon branch and biomass. The effect of genotype on plant morphology was significant for all the parameters studied. This implies that phosphorus and rhizobium were not effective in isolation but the effect of their interaction with genotype was significant. Significant variation for plasticity among genotypes was also reported by Caradus *et al.* (1983).

The difference in tolerance to phosphorus by the genotypes can be determined on the basis of

Table 3(a). Mean yield and response to P fertilizer of selected genotypes

Genotype	Clover yield (g)	L/H ratio	Leaflet width
L10	92.998	1.171	0.54
L13	120.460	0.960	0.69
L19	199.380	0.929	0.84
L23	189.590	0.987	0.56
L27	78.428	1.407	0.63
L99	56.355	1.443	0.64
L100	29.405	1.718	0.66

Table 3(b). Mean yield and response to rhizobium of selected genotypes

Genotype	Clover yield (gm)	L/H ratio	Leaflet width
L10	92.995	0.901	0.54
L13	107.955	0.861	0.69
L19	240.25	1.103	0.84
L23	189.585	0.996	0.56
L27	79.315	0.714	0.63
L99	56.355	1.050	0.64
L100	29.405	0.567	0.66

variation in P response. Phosphorus response is broadly defined as change in dry matter yield with increase in P supply and can be measured as a ratio of yield at low P divided by yield at an adequate level of phosphorus supply (Caradus, 1994) or by using fitted curves (Caradus *et al.* 1992). During the present study, we compared the genotypes by finding the ratio of biomass at low P and high P level. The genotypes L100, L99, L27 and L10 were more productive at low phosphorus level (Tables 3a and 3b). Similarly, we compared the biomass yield in presence and absence of rhizobium. The genotypes L19 and L99 were more productive without rhizobium treatment.

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SPECTRAL MONITORING AND YIELD PREDICTION OF COTTON

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ABSTRACT

Remote sensing technology is an important tool for monitoring crop growth and development. It also provides accurate and timely information about the crop yield. Result showed that LAI, plant height, total dry matter and dry matter partitioning are significantly correlated with spectral indices like radiance ratio (RR) and normalized difference vegetation index (NDVI). The correlation coefficient (r) values are improved with second degree model over that of simple linear model and are further improved under multiple linear model, in which days after sowing (DAS) was added as independent variable. Spectral indices and plant growth parameters except LAI and chlorophyll content are better correlated with *Desi* cotton as compared to American cotton and *vice versa.* The integrated spectral indices and plant growth variables are highly significantly correlated during 51-80 DAS Yield attributes like number of flowers per plant, number of unopened bolls/plant, number of total bolls/plant have been found more significantly correlated with spectral indices during 81-110 DAS The quadritic regression equation for American and *Desi* cotton yield over integrated spectral indices in different time segment periods show that American cotton is best correlated with RR and *Desi* cotton is best correlated with NDVI. The minimum percent diviaton between predicted yield from spectral parameters and actual yield are obtained during 81-110 DAS. It showed that the yield of American or *Desi* cotton could be estimated from spectral parameters during maximum vegetable growth stage with maximum 5 per cent deviation from actual yield.

Keywords : Spectral indices, radiance ratio, NDVI, growth parameters, American cotton (*Gossypium hirsutum*), desi cotton (*G. arboreum*), yield.

Cotton plays an important role in agrarian and industrial economy of a country. The timely and accurate cotton production prediction is necessary for better management in procurement strategy of this crop.

Measurement of leaf area index (LAI) and other agronomic parameters of the crop by conventional methods is time consuming, especially when the measurements are required throughout the growth cycle of the crop. Spectral measurements from crops have shown promise for use in estimating these parameters and monitoring the changes during the growth cycle of the crop. The strong relationship between spectral reflectance and several crop canopy variables demonstrate the potential of multi-spectral remote sensing to monitor crop growth and condition (Khawas and Bhattacharjee, 1996). Definite relationships have been found between LAI and reflectance measurements for various measurements for various crops (Czarnowski and Cebula, 1996). Vegetation index can be used to predict LAI in cotton (Kustas *et al.* 1993).

To utilize the full potential of remote sensing for monitoring the crop condition and yield prediction, it is essential to quantify the relationship between agronomic parameters and spectral properties of the crop. There is a lack of work on monitoring of cotton crop condition and cotton yield prediction.

MATERIALS AND METHODS

An experiment was conducted on cotton crop during 1997-98 *kharif* season on a sandy loam soil at the experimental farm of the Punjab Agricultural University, Ludhiana. It is situated at latitude of 30°56' N, longitude of 75°52' E and altitude of 247 meters. The soil was neutral in reaction and normal in salt concentration (upto the depth of 60 cm) but it increased with depth of investigated 120 cm. The organic carbon content was moderate at the surface (0-15 cm) and lower in the sub-surface (15-120 cm). The soil was low in available nitrogen, medium in available phosphorus and high in available potassium content throughout the profile.

The experiment was laid out in split-plot design with two cotton species {American cotton (*Gossypium hirsutum*) and Desi cotton (*G. arboreum*)} and two dates of sowing (May 1 and May 29) in the main plot and five nitrogen levels (viz., 0, 40, 80, 120 and 160 kg N/ha) in the sub-plot replicated three times.

The cotton (American cotton cv. F 846 and *Desi* cotton cv. LD 327) was sown in the plots measuring 10.0 m x 4.5 m with 67.5 cm row to row spacing. Half of the N (in the form of urea) was applied at sowing and rest half at the appearance of first flower. 30 kg P_2O_5/ha in the form of single super phosphate was drilled at the time of sowing. The first irrigation was given after 30 days for establishment of the crop and subsequent six irrigations were applied during crop growth season. First picking was done in 3rd week of September and 2nd week October of May 1 and May 29 sown crops, respectively. Last picking was done in 3rd week of November for both date sown crop.

Spectral reflectance measurements were recorded between 0930 and 1130 hours in direct sunlight using an indigenously developed hand held operated Multiband Ground Truth Radiometer (GTR 12-0.4) in tow spectral bands, red (R) (625-689 nm) and infrared (IR) (760-897nm). The spectral measurements were taken fortnightly interval, starting from 35 DAS (day after sowing) to maturity and taken total 12 (twelve) dates observation throughout crop growth periods. Six to eight measurements were made on each experimental plot with radiometer elevated 1 m vertically above the top of the crop canopy surface. All spectral measurements were normalized with the irradiance obtained by BaSo4 standard. The radiance ratio (RR=IR/Red) and normalized difference vegetation index [NDVI=(IR-Red)/(IR+Red)] were calculated.

Growth parameters *i.e.* plant height, total dry matter and dry matter partitioning, leaf area index (LAI), etc. were measured concurrently with the spectral data. The yield attributing parameters and phonologies were also taken to correlate with spectral vegetation indices. The total yield of all the picking was expressed in tones per hectare (t/ha).

The growth and yield attribute parameters were correlated with vegetation indices, using the three models viz., sample linear (model A), quadratic (model B) and multiple linear (model C) in which days after sowing (DAS) was used as additional variable. Further, the RR and NDVI were integrated over different periods during the growing season to study the feasibility of remote sensing application of the leaf area duration concept. The vegetation indices were integrated over the periods 0.50, 51-80, 81-110, 111-140 and 141-200 DAS. These integrated values were then correlated with the growth and yield parameters of American and *Desi* cotton, separately. These integrated values were also correlated with the seed cotton yield using all the three models.

RESULTS AND DISCUSSION

Relationship between spectral and agronomic/yield attributes parameters

Throughout crop growth, the 'r' values showed that spectral indices are significantly correlated with agronomic variables in simple linear model. The correlation values further improved with second-degree model B. For plant height, LAI, leaf dry matter and chlorophyll content, 'r' values further improved under model C in both cotton species. The parameters like LAI, plant height, and leaf dry matter are highly correlated with RR and NDVI among various agronomic parameters. Reproductive dry matter is not correlated with RR and NDVI. In general, the NDVI is more correlated with agronomic parameters in both cotton species except LAI and chlorophyll content, which are more linearly and quadratically correlated with RR.

In American cotton, number of flower, unopened bolls and total bolls per plant are found significantly correlated with RR in all three A, B and C models. The 'r' values between yield attributes and NDVI under model C are found highly significant and improved over A and B models. In *Desi* Cotton, number of unopened bolls and total bolls per plant are found significant correlated with RR under all three models and values are improved from model A to C. But these yield attributes are not significantly correlated with NDVI under model A model A and B. However, all the yield attributes significantly correlated in model C. leaf are index, plant height, total dry matter and dry matter partitioning are highly correlated with the spectral parameters and may be used to predict from spectral parameters. Therefore, its continuous monitoring during the crop growth season is necessary.

Integrated values over time

In the American cotton, total dry matter, plant height, LAI, stem and leaf dry matter are found to be highly correlated with spectral parameters during sowing to 110 DAS with RR and sowing to 140 DAS with NDVI. The correlation coefficient values between RR or NDVI and above mentioned growth parameters were highest during 51 to 80 DAS, while 'r' values between spectral indices and yield attributes like number of flowers, unopened bolls and total bolls per plant are highest during 81 to 110 DAS. The 'r' values showed that spectral indices and yield attributes are significantly correlated in later growth stages *i.e.* from 81 DAS to maturity. The NDVI is relatively more correlated than RR with growth parameters during 51-80 DAS and with LAI and root dry matter during 141-200 DAS. Also NDVI is more correlated than RR with yield attributes during 141-200 DAS.

In case of *Desi* cotton, similar trend was observed as in American cotton. Growth. Parameters like plant height, LAI, total dry matter, stem dry matter and leaf dry matter are found highly correlated with both RR and NDVI up to 110 DAS and 141-200 DAS and maximum values were observed during 51-80 DAS. Yield attributes were significantly correlated with RR with NDVI during 141-200 DAS. While number of unopened bolls per plant were highly correlated during 81-140 DAS; and total number of boll per plant are highly correlated with NDVI during 81-140 DAS. The integrated values of growth parameters and yield attributes were correlated with integreated RR and NDVI at different phenological stages.

Yield prediction

The quadratic regression equation for American and *Desi* cotton yield over integrated spectral indices in different time segment periods are presented in Table 1. In third time segment periods i.e. 81-110 DAS, the 'r' values are found highly significant than any other time segment periods. In American cotton, the 'r' values were found highly significant than any other five segment priod. In American cotton, the 'r' values were 0.92 and 0.81, respectively for RR and NDVI during 81-110 DAS time segment. In *Desi* cotton, 'r' values are the same *i.e.* 0.88 for both RR and NDVI during above time segment.

The predicted American cotton yield was calculated over actual mean yield over different time segment period (Table 2). It was found that minimum deviation was obtained during 81-110 DAS as compared to all other time periods for both spectral variables in both cotton species. It was also observed that least deviations were obtained in RR as compared to NDVI during all time segments. Least deviation was observed in *Desi* cotton, at third time segment as compared to American cotton.

The 'r' values showed that American and *Desi* cotton were highly correlated with RR and NDVI in quadratic model. It showed that quadratic regression equation using RR or NDVI as a variable (Ansari *et al.* 1999) may be used to estimate the American and *Desi* cotton yields during maximum vegetative growth stage (81-110 DAS). Remote sensing (RS) has a potential tool for obtaining accurate and timely information about the condition and yield of crops (Bauer, 1975).

Thus, the spectral parameters like RR and NDVI can be used to monitor growth and development of American and Desi cotton. Leaf area index, plant height, total dry matter and dry matter partitioning are significantly correlated with spectral indices like radiance ratio (RR) and normalized difference vegetation index (NDVI). The yield of American and *Desi*

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Table 1.Regression analysis between seed cotton yield (Y) and integrated spectral indices (X) of American and *Desi* cotton in quadratic model

Time segment (DAS)	RR				NDVI			
	a	b	b_1	r	a	b	b_1	r
American Cotton								
0-50	6.071	6.736	-1.740	0.37	10.797	11.347	-21.040	0.34
51-80	0.273	3.994	-0.485	0.48	0.933	39.545	-34.239	0.38
81-110	-18.861	11.382	-1.013	0.92**	-151.328	149.280	-112.570	0.81**
111-140	-3.862	7.231	-0.788	0.71*	-37.029	474.430	-342.780	0.59**
141-200	-8.667	13.872	-2.249	0.62**	-53.143	229.300	-199.980	0.65**
***Desi* Cotton**								
0-50	11.812	3.880	-0.841	0.33	14.250	13.172	-22.165	0.38
51-80	6.775	4.170	-0.406	0.50	1.545	46.436	-36.621	0.37
81-110	-16.866	9.390	-0.651	0.88**	-262.280	750.485	-504.756	0.88**
111-140	-4.389	6.506	-0.498	0.84**	-74.694	249.901	-171.401	0.63*
141-200	2.872	5.480	-0.554	0.54*	-132.88	446.000	-334.000	0.76**

$^*\alpha=0.05$ $^{**}\alpha=0.01$

Table 2. Comparison of actual and predicted (t/ha) and per cent deviation of Amecican and *Desi* cotton for both spectral indices (RR or NDVI) at different time segment

	0-50 DAS		51-80 DAS		81-110 DAS		111-140 DAS		141-200 DAS	
Actual yield	Predicted yield	Per cent deviation*	Predicted yield	Per cent deviation	Predicted yield	Per cent deviation	Predicted yield	Per cent deviation	Predicted yield	Per cent deviation
American Cotton										
RR										
1.062	1.172	10.36	1.149	8.19	1.057	-0.47	1.108	4.33	1.128	6.21
1.178	1.204	2.21	1.198	1.70	1.221	3.65	1.198	1.70	1.210	2.71
1.354	1.217	-10.12	1.225	-9.53	1.293	-4.51	1.256	-7.24	1.249	-7.75
1.278	1.208	-5.98	1.224	-4.23	1.297	1.49	1.261	-1.33	1.230	-3.76
1.125	1.196	6.31	1.201	6.76	1.129	0.36	1.175	4.44	1.180	4.89
NDVI										
1.062	1.167	9.89	1.157	8.95	1.066	0.38	1.096	3.20	1.092	2.82
1.178	1.197	1.61	1.198	1.70	1.239	5.18	1.209	2.63	1.220	3.57
1.354	1.209	-10.70	1.212	-10.49	1.281	-5.39	1.216	-10.19	1.245	-8.05
1.278	1.215	-4.93	1.215	-4.93	1.246	-2.50	1.257	-1.64	1.233	-3.52
1.125	1.210	7.56	1.215	8.00	1.165	3.56	1.204	7.02	1.209	7.47
***Desi* Cotton**										
RR										
1.389	1.550	11.60	1.522	9.57	1.410	1.51	1.425	2.59	1.506	8.42
1.584	1.573	-0.69	1.588	0.25	1.584	0.00	1.557	-1.70	1.576	-0.51
1.750	1.588	-9.26	1.628	-6.97	1.682	-3.89	1.664	-4.91	1.612	-7.89
1.656	1.603	-3.20	1.612	-2.66	1.667	-0.6	1.684	1.69	1.618	-2.29
1.534	1.598	4.17	1.588	3.52	1.659	2.28	1.583	3.19	1.600	4.30
NDVI										
1.389	1.542	11.02	1.545	11.02	1.397	0.58	1.482	6.70	1.412	1.66
1.584	1.575	-0.57	1.576	-0.58	1.605	1.33	1.569	-0.95	1.599	0.95
1.750	1.593	-8.97	1.589	-9.20	1.683	-3.83	1.628	-6.97	1.629	-6.91
1.656	1.607	-2.96	1.599	-3.44	1.642	-0.85	1.628	-1.69	1.646	-0.60
1.534	1.597	4.11	1.599	4.24	1.582	3.13	1.599	4.24	1.608	4.82

*Per cent deviation from the actual yield cotton may be predicted spectrally from RR or NDVI during 81-110 DAS *i.e.* 3 months before harvest with maximum 5 per cent deviation from actual yield.

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EVALUATION AND CHARACTERIZATON OF SCENTED RICES FOR GRAIN QUALITY CHARACTERS

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ABSTRACT

Twenty scented rice varieties along with a national cheak Pusa Basmati-1 were evaluated for various physico-chemical characters to their possible use as donors in rice quality improvement programmes as well as for consumption and export purposes. Varieties showed wide range of variation for aroma and chalkiness of endosperm indicating broad scope for improvement through selection. The highest kermel length was recorded in Khao Dowk Mali 105 (8.33 mm) followed by KCN 80152 (7.89 mm) and Hawa Kikwai (7.72 mm) which may be utilized as donors for developing long grains varieties. Overall five varieties, namely Khao Dawk Mail 105, Pakistani Basmati, Khao Hawn, Basmati Sathi and Basmati Champaran were identified superior among all of them as well as over Pusa Basmati-1 for most of the quality characters, which can be used as donors for quality improvement as well as for consumption and export purposes.

Key words : Scented rices, characterization, grain quality characters.

Rice is the important staple food consumed by more than a half of the world's population. India has largest area and got second rank in rice production among the rice growing countries. However, its share for export in international market is less than five percent due to lacking grain quality characteristics. Rice quality include head rice recovery, kernel size, shape and appearance, gelatinization temperature, anylose content, kernel elongation ratio, water uptake number, volume expansion and aroma. Scented rices have important place to earn more foreign currency due to its pleasant aroma, super fine grain, excellent cooking and eating quality, and also preferred by the consumers in our nation. Hence, it is necessitates to improve grain quality of modern rice varieties to fulfil the demand of consumes in domestic as well ad international markets. Efforts are being made in India to develop scented as well as non-scented quality rices, however, successful utilization of hybrid technology in China, encouragd to Indian scientists to develop aromatic rice hybrids by using better parents possessing desirable grain quality characters. Generally hybrids showed intermediate quality characters over their parents (Khush *et al.* 1988). Howerver, information on quality aspects of aromatic rices is limited. Hence, in the present study attempts have been made to evaluate and characterize aromatic rice varieties for various physicochemical traits, which can be useful as donors for quality improvement as well as for domestic and export purposes.

MATERIALS AND METHODS

The experimental material consists of a set of 20 scented rice varieties and a national check Pusa Basmati-1 were obtained from Directorate of Rice Research, Hyderabad. These varieties alsong with check were grown in a randomized block design with three replications during *Kharif*, 2001 at Agricultural Research Farm of Banaras Hindu Universtiy, Varanasi. A single seedling of each genotype was transplanted in 3m row length adopting 20 cm distance between rows and 15 cm between plants. All the recommend agronomic practices were followed to raise good crop.

A composite sample of ten randomly

Present Address : Department of Genetics & Plant Breeding, Amar Singh (P.G.) College, Lakhaoti, Bulandshahr-245407 selected plants from each replication was used to record observations on quality characters, viz., hulling, milling, head rice recovery, kernel length, kernel breadth, L/B ratio, kernel elongation, aroma, water up take number, volume expansion, gel consistency, alkali digestion value and amylose content. Seeds hulled in Stake huller and milled in KETT rice polisher. Unbroken kernels obtained from milling were used to calculate head rice recovery, kernel length and breadth were measured by dial micrometer, and ratio of kernel length to kernel breadth was computed as kernel L/B ratio of cooked rice to mean L/B ratio of milled rice. Aroma was detected in leaves as well as kernel by method of Nagaraju *et al.* (1991). The cooking quality parameters, namely alkali digestion value, water uptake numbers, volume expansion, gel consistency and amylose content were measured by standard methods of Little *et al.* (1958), Hallick and Kelly (1959), Onate and Del Mundo (1966), Cagmpang *et al.* (1973) and Bhattacharya and Sowbhaggya (1971), respectively. The range, mean, and coefficient of variation (CV%) were computed following standard statistical methods.

RESULTS AND DISCUSSION

The hulling, milling and head rice recovery are the important grain quality characters from commercial point of view, which increase the market value. Hulling and milling recovery was ranged from 53.68 to 86.53% and 50.9 to 78.89%, respectively (Table 1). However, low variability was observed in varieties for hulling and milling indicating little scope for improvement of these characters through selection. Chauhan *et al.* (1991) also reported low variability for hulling and milling recovery. The highest hulling recovery was recorded in Niaev Ping (86.53%) followed by Tulsi Majari (82.55%), Gopal Bhog (81.4%) and Basmati -397 (81.37%), whereas highest milling was observed in Gopal Bhog (78.89%) followed by Niaev Ping (74.84%), Tulsi Manjari (73.3%) and Seeta Sail (73.22%). These varieties possessed higher hulling and milling recovery (Table 1) can be used as donors for breeding varieties with higher hulling and milling recovery. Out of 20, five varieties, *viz.*, Niaev Ping, Basmati 397, Gopal Bhog, RD 15 and Tulsi Manjari were found significantly superior over Pusa Basmati-1 for hulling recovery whereas two varieties Niaev Ping and Gopal Bhog Showed superiority for milling over Pusa Basmati-1. The commercial viability of rice mainly depends on head rice recovery which was ranged in varieties from 27.45 to 66.65% with low variability indicating little scope for improvement of this characer. Similar findings were also reported by Arumugachmy *et al.* (1995). The highest head rice recovery was recorded in Niaev Ping (66.65%) followed by Gopal Bhog (56.99%) and Khao Hawn (58.72%), which can be useful as donors for developing rice varieties with higher head rice recovery. Out of 20, six varieties *viz.*, Niaev Ping, AC 25419, Khao Hown, Gopal Bhog, Basmati Champaran and Tulsi Manjari Showed higher head rice recovery than Pusa Basmati-1, which may be useful for export purposes if have other desirable quality characters. Grain size and shape are important quality characters in determining market value of rice. Extra long to medium slender are much more preferred by the growers, traders and consumers. Varieties showed low variation for kernel length and L/B ratio with the range from 5.51 to 8.30 mm and 2.45-4.53, respectively. Chauhan *et al.*, (1991) also reported low variability for kernel length, whereas who reported moderate variability for L/B ratio. Results indicating that little change of improvement to kernel length and L/B ratio through selection. The higher kernel length was recorded in Khao Dowk Mali-105 (8.33 mm) followed by KCN 80152 (7.89 mm, Hawn Kikwai (7.72 mm) and Pusa Basmati-1 (7.71 mm), whereas, highest L/B ratio was recorded in Pusa Basmati-1(4.53) followed by Hawn Kikwai (4.33), Khao Dawk Mali 105 (4.21) and KCN 80152 (4.19). Varieties with higher kernel length and L/B ratio may be utilized as donors for breeding long grain varieties. Two varieties, Khao Dawk Mali 105 and KCN 80152 were found significantly superior over Pusa Basmati-1 for kernel length, whereas some varieties, namely Hown Kikwai, Khao Dawk Mali 105 and KCN 80152 were at par with Pusa Basmati-1 for these characters. These varieties may be useful as domestic as well as export purposes if have other desirable quality characters.

Table 1. Analysis of variance for 14 characters

Varieties	Hulling (%)	Milling (%)	Head rice recovery (%)	Kernel length (mm)	Kernel breadth (mm)	Kernel L/B ratio	Kernel elongati on ratio	Aroma (0.2)	Chalkiness of endosperm (0-9)	Alkali digestion value (1-7)	Water uptake number (ml)	Volume expansion	Gel consistency (mm)	Amylose content (%)
Pusa Basmti 1	73.12	65.74	50.37	7.71	1.70	4.53	1.99	3.0	1.0	7.00	373.33	3.54	41.00	24.26
Daev Leuana	69.38	60.10	51.66	6.67	2.14	3.11	1.65	2.0	2.0	6.94	151.00	2.50	29.00	23.73
Khao Hawn	70.14	67.35	58.72	7.27	2.37	3.21	1.87	2.0	2.0	4.00	302.67	4.80	33.00	22.67
Niaev Ping	86.53	74.84	66.65	5.51	2.24	2.45	1.48	2.0	4.0	3.20	180.33	2.60	40.00	24.25
Sadri	75.19	64.26	54.14	6.39	2.21	2.89	1.63	2.0	6.0	3.33	256.67	4.40	38.00	23.20
Seeta Sail	77.05	73.22	40.57	7.29	1.95	3.76	1.88	3.0	1.0	3.00	205.67	3.20	30.00	22.70
Basmati 134	75.08	66.11	39.60	7.51	1.94	3.87	1.87	3.0	4.0	3.00	378.33	5.40	38.00	22.33
Basmati 397	81.37	70.82	27.45	7.56	1.96	3.80	1.89	3.0	6.0	4.00	203.67	4.20	33.00	21.22
Khao Dawk-Mali-105	72.71	67.91	41.10	8.30	1.97	4.21	1.88	2.0	2.0	5.81	189.67	4.60	41.33	21.34
Hawn Kakwai	73.78	63.28	34.75	7.72	1.78	4.33	1.82	3.0	4.0	2.77	244.00	4.30	44.00	22.62
Patloon Tahni	74.13	58.16	28.14	6.55	2.27	2.88	1.89	3.0	8.0	3.00	428.00	6.20	37.00	22.66
KCN 80152	71.98	50.99	35.84	7.89	1.88	4.19	1.88	2.0	4.0	2.83	409.33	6.03	35.00	23.20
Pakistani Basmati	72.71	54.71	53.20	7.67	1.90	4.03	1.87	3.0	1.0	2.83	367.67	4.41	35.67	24.78
AC 25419	76.67	59.78	60.76	6.18	2.17	2.84	1.85	2.0	4.0	4.00	150.67	2.40	44.00	21.62
Basmati Sathi	53.68	60.76	42.49	6.62	2.11	3.13	1.87	2.0	2.0	3.50	206.00	3.20	32.00	22.68
Gopal Bhog	81.40	78.89	59.99	6.49	2.05	3.16	1.88	3.0	6.0	4.27	354.67	5.20	33.00	23.20
RD 15	80.50	71.00	43.88	6.43	1.95	3.29	1.70	2.0	6.0	2.72	388.33	6.20	36.00	21.62
Domsiah	76.53	72.45	35.35	7.60	2.83	3.68	1.85	2.0	2.0	2.50	178.00	2.90	96.00	18.25
Basmati-Champaran	72.92	56.21	56.21	7.35	2.05	3.58	1.87	2.0	6.0	3.81	296.00	3.00	52.00	23.73
Prasadbhog	71.23	72.28	54.20	6.48	2.07	3.15	1.72	3.0	4.0	2.53	175.67	3.00	36.00	19.21
Tulsi Manjari	82.55	73.30	57.79	5.53	2.19	2.52	1.66	2.0	4.0	4.00	318.33	4.00	30.00	21.09
C.D. (5%)	8.057	9.043	4.743	0.296	0.085	0.254	0.015	0.917	0.910	0.459	3.943	0.405	0.225	0.561
Range	53.68 to 86.53	50.99 to 78.89	27.45 to 66.65	5.51 to 8.30	1.70 to 2.83	2.45 to 4.53	1.81 to 1.99	1 to 3	1 to 8	2.5 to 7.0	150.67 to 428.00	2.40 to 6.20	28.99 to 96.00	18.25 to 24.78
Mean	74.86	65.85	47.78	6.94	2.07	3.43	1.81	2.38	3.77	3.72	279.40	4.03	39.22	22.41
C.V. (%)	6.57	8.36	6.38	2.51	2.57	4.45	0.53	29.90	19.94	7.43	8.59	6.12	7.22	1.52

Table 2. Characterization of aromatic varieties for certain quality characters

Varieties	Head rice recovery	Water uptake number	Volume expansion	Grain size and shape	Kernel elongation	Aroma	Gelatinization temperature	Gel consistency	Amylose content
Pusa Basmati 1	Intermediate	High	Low	Extralong slender	High	Strong	Low	Medium	Intermediate
Daev Leuana	Intermediate	Low	Low	Long slender	Intermediate	Intermediate	Low	Medium	Intermediate
Khao Hawn	High	Intermediate	Intermediate	Long slender	High	Intermediate	High intermediate	Midium	Intermediate
Niaev Ping	High	Low	Low	Medium medium	Low	Intermediate	High	Medium	Intermediate
Sadri	High	Intermediate	Intermediate	Medium medium	Intermediate	Intermediate	High	Hard	Intermediate
Seeta Sial	Low	Low	Low	Long slender	High	Strong	High	Hard	Intermediate
Basmati 134	Low	High	High	Extra long slender	High	Strong	High	Hard	Intermediate
Basmati 397	Low	Low	Intermediate	Extra long slender	High	Strong	High	Hard	Intermediate
Khao Dawk Mali 105	Intermediate	Low	Intermediate	Extra long slender	High	Intermediate	Intermediate	Medium	Intermediate
Hawn Kikwai	Low	Intermediate	Intermediate	Extra long slender	High	Strong	High	Medium	Intermediate
Patloon Tahni	Low	High	High	Medium medium	High	Strong	High	Hard	Intermediate
KCN 80152	Low	High	High	Extra long slender	High	Intermediate	High	Hard	Intermediate
Pakistani Basmati	Intermediate	High	Intermediate	Extra long slender	High	Strong	High	Hard	Intermediate
AC 25419	High	Low	Low	Medium medium	High	Intermediate	High Intermediate	Medium	Intermediate
Basmati Sathi	Intermediate	Low	Low	Long slender	High	Intermediate	High Intermediate	Hard	Intermediate
Gopalbhog	High	High	High	Medium slender	High	Strong	HighIntermediate	Hard	Intermediate
RD 15	Intermediate	High	High	Medium slender	Intermediate	Intermediate	High	Hard	Intermediate
Domsiah	Low	Low	Low	Extra long slender	High	Intermediate	High	Soft	Low
Basmati Champaran	High	Intermediate	Low	long slender	High	Intermediate	High Intermediate	Medium	Intermediate
Prasadbhog	High	Low	Low	Medium slender	Intermediate	Strong	High	Hard	Low
Tulsi Manjari	High	Intermediate	Intermediate	Medium slender	Intermediate	Intermediate	High Intermediate	Hard	Intermediate

Kernel elongation is important cooking quality character, and its higher values are desirable and much preferred by the traders and consumers. Low variability was also observed for kernel elongation with the range from 1.48 - 1.99. These findings are contradictory to Chauhan *et al.* (1991) who reported moderate variability for this character. Maximum kernel elongation was observed in Pusa Basmati-1 (1.99) followed by Basmati 397 (1.89), and Khao Dawk Mali 105, KCN 80152 and Gopal Bhog (1.88). These varieties can be used as donors for quality improvement. Aroma is important economic trait of quality rices mostly preferred by the consumers and traders in domestic as well as international markets. High coefficient of variation for aroma was observed in varieties with the range from medium to strong which indicates a broad scope for improvement of this character. Out of 20, six varieties *viz.*, Basmati 134, Basmati 397, Patloon Tahni, Hawn Kikwai, Pakistani Basmati and Gopal, Bhog have strong aroma, which can be used as donors for developing aromatic varieties and hybrids. Alkali digestion value is the important cooking quality determinant and its intermediate score (4-5) are useful to quality point of view. It was ranged from 2.5 to 7.0 with low variation. The varieties *viz.*, Gopal Bhog, Khao Hawn, Basmati 397, AC 25419 and Tulsi Manjari have intermediate alkali digestion value which can be utilized as donors for developing varieties in the desirable gelatinization temperature. The water uptake and volume expansion are also major quality components increasing acceptance by consumers with their higher values. Both were ranged in varieties from 150.6 to 428.0 ml and 2.4 to 6.2 ml, respectively. The low variability was observed in varieties for these character indicating little scope for improvement through selection. Similar findings were also reported by a Chauhan *et al.* (1991). The highest water and Nanda *et al.* (1999) uptake number was recorded in Patoon Tahni (428.00 ml) followed by KCN - 80152 (409.3 ml), RD 1 (388.3 ml) and Basmati - 134 (378.3 ml), whereas highest volume expansion was observed in Patloon Tahni and RD -15 (6.2) followed by KCN 80152 (6.03), Basmati, 134 (5.4) and Gopal Bhog (5.20). These varieties can be utilized as donors for developing rice varieties with higher water uptake an volume expansion. The gel consistency and amylose content are also important chemical quality characters which make cooked rice to be flaky, fluffy and soft, their soft to medium, and intermediate values are desirable. These were ranged from 29.0 to 96.0 mm and 18.25 to 24.78%, respectively, with low variation for both the characters. Similar findings were also reported by Chauhan *et al.* (1991). The variety, Domsiah showed highest gel consistency (96.0mm) followed by Basmati Champara (52.0 mm), Hawn Kikwai and AC 25419 (44.00mm), Khao Dawk Mali 105 (41.0 mm) and Niaev Ping (40.0mm), whereas Pakistani Basmati had highest amylose content (24.78%) followed by Pusa Basmati-1 (24.26%), Niaev Ping (24.25%) and Basmati Champaran (23.73%) which can be utilized as donors for breeding varieties with their acceptable level. Five varieties viz, Khao Dawk Mali 105, Hawn Kikwai, AC 25419,Domsiah and Basmati Champaran were observed significantly superior over Pusa Basmati-1 for gel consistency. Whereas Pakistani Basmati and Niaev Ping were found at par with Pusa Basmati-1 for gel consistency. In the present study, high coefficient of variation was observed for aroma and chalkiness of endosperm in varieties indicating broad scope for improvement of these characters. However, remaining quality characters showed little variation, but individually varieties exhibited better performance for most of the quality attributes. Over all five varieties, namely Khao Dawk Mali 105, Pakistani Basmati, Khao Hown, Basmati Sathi and Basmati Champaran (Table 2) indentified superior among all of them as well as over Pusa Basmati-1 for most of the quality characters, which can be used as donors for quality improvement as well as for domestic and export purposes.

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HETEROSIS IN LONG GRAINS AROMATIC RICES FOR YIELD AND QUALITY COMPONENTS

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ABSTRACT

Two CMS lines, IR 68888A and IR68891 A were crossed with six long grains (6.63 to 7.73 mm) aromatic rice varieties and resultant twelve hybrids were evaluated with better parent and standard check, Pusa Basmati-1 for different yield and quality characters. Out of 12, four hybrids exhibited significant negative standard heterosis for days to maturity, whereas out of which one hybrid, IR6888A x PB-5-14-50-1 also showed significant negative standard heterosis for plant height. The heterobeltiosis and standard heterosis for grain yield per plant in hybrids ranged from 11.72 to 89.29% and 18.48 to 104.7%, respectively. Six hybrids exhibited higher degree of heterrobeltiosis and standard heterosis for grain yield. Overall three hybrids viz., IR68888AxPB-6-12-24-4, IR68888AxPB-5-14-50-1 and IR68888 Ax Hawn Kikwani in the present study were identified superior over standard check for most of the yield and quality characters whereas two hybrids, IR68888xAPB-6-12-24-4 and IR68891AxPB-8-48-59-2 showed high heterosis as well as high outcrossing potential which can be exploited further in hybrid rice breeding programme.

Key words : Aromatic rices, long grains, heterosis, yield and quality characters.

Quality rices have important place in domestic as well as international markets due to its superfine grains, pleasant aroma, soft texture, excellent cooking and eating quality which is much preferred by the consumers, and earns more foreign currency by their export. However, its share in total export is much below than the non-aromatic varieties. Hence, intensive efforts are needed to increase the productivity of aromatic rices with acceptable grain quality, so that they can be popularised outside the country, and also to meet the requirement of domestic market where it sells on higher prices. The options are limited to increase productivity of aromatic rices, one such option hybrid technology can be useful for developing rice hybrids with acceptable grain quality by using long grains parents with desirable grain quality characters. Since, producing long grains hybrids required both the parents of long gains (Khush *et al.* 1988). The higher cost of hybrid seed is major constraint for extension of hybrid varieties to commercial cultivation, however it can be minimized by using CMS lines with high outcrossing potential to produce huge quantity of hybrid seed. Hence, in the present study attempts have been made to develop heterotic long grains rice hybrids by using long grains parents, and also assess the outcrossing potential of CMS lines with different restorers.

MATERIALS AND METHODS

During the Kharif season of 2000, twelve hybrids were obtained by crossing of two CMS lines, IR 6888A and IR68891A with six long grains (6.63 to 7.73 mm) aromatic pollen parents viz., Hawn Kikwai, Gopal Bhog, PG-8-48-59-2, PB-6^{-1}2-24-4, PB-6^{-1}-60-9 and PB-5^{-1}4-50^{-1} in line x tester fashion, and they were evaluated in a randomized block design with three replications during *Kharif*, 2001 at Agricultural Research Farm of Banaras Hindu University, Varanasi. Each entry per replication was transplanted in a single row of 3 m length with a spacing of 20 cm between rows and 15 cm between plants and all the recommended agronomic practices were followed to raise good crops. The observations on yield and its components viz, days to maturity (DM), plant height (PH), number panicles^{-1} (NPP), panicle length (PL), grains panicle^{-1} (GP), grain weight (TW) and grain yield^{-1} (GYP) were recorded from ten randomly selected plants in each replication, whereas grain quality characters namely, head rice recovery (HRR), kernel length (KL), kernel breadth (KB), L/B ratio (L/B), kernel elongation (KE), alkali digestion value (AKD), water uptake number (WUP), volume expansion (VE), gel consistency (GC), amylose content (AC) and aroma were observed form a composite seed sample of ten randomly selected plants per replication. The head rice recovery was calculated by entire unbroken kernels obtained from milling. The kernel length and breadth were measured by dial micrometer and ratio of kernel length to kernel breadth was computed as kernel L/B ratio. The kernel elongation ratio was measured by ratio of cooked and milled kernel length. Aroma was detected in leaves as well as kernels by using method of Nagaraju *et al.* (1991). The cooking quality parameters *viz.,* alkali digestion value, water uptake number, volume expansion, gel consistency and amylose content were measured by using standard methods of Little *et al.* (1958), Halick & Kelly (1959), Onate & Del Mundo (1966), Cagampang *et al.* (1973) and Bhattacharya & Sowbhagya (1971), respectively. The heterobeltiosis and standard heterosis were estimated as percent increase or decrease of F1 values over better parent and standard check, respectively. The mean performance and extent of heterosis for yield and grain quality characters of twelve hybrids were presented in Table 1.

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RESULTS AND DISCUSSION

The days to maturity and plant height both are the important traits for commercial point of view and negative heterosis is desirable for these characters. The estimates of heterobeltiosis and standard heterosis of days to maturity in rice hybrids were ranged from-6.4 to 16.2% and-12.29 to-3.58%, respectively. Out of 12, four hybrids exhibited significant negative standard heterosis for this character, which included IR68891AxPB-6-12-24-4, IR 68888AxPB-6-1-60-9, IR68888AxPB-8-48-59-2 and IR68888AxPB-5-14-50-1. Simliar findings were also reported by Sarma and Roy (1996). For plant height, heterobeltiosis and standard heterosis ranged from 5.23 to 72.73% and-19.18 to 28.88%, respectively. One hybrid, IR68888AxPB-5-14-50-1 showed significant negative standard heterosis for plant height. These findings are in conformity with earlier findings of Vishwakarma *et al.* (1999) who also reported significant negative standard heterosis for plant height. On the basis of mean per se performance, three hybrids namely, IR68888AxPB-5-14-50-1, IR68888AxPB-6-12-24-4 and IR68888Ax PB-8-48-59-2 exhibited as short plant stature. The heterobeltiosis and standard heterosis in rice hybrids for panicles plant^{-1} ranged from 19.42 to 74.54% and 1.97 to 60.83%, respectively. Out of 12, eight hybrids exhibited significant positive standard heterosis for this character which included IR68888Ax Hawn Kikwai, IR68888 Ax PB-6-1-60-9, IR 68891 A X PB-6-1-60-9 and IR68888A x PB-8-48-59-2. Vishwakarma *et al.* (1999) also reported significant positive as well as negative heterobeltisis for number of panicles plant^{-1}, whereas our findings on standard heterosis are contradictory to their results because who reported both significant positive as well as negative standard heterosis for this character. For grains panicle^{-1}, heterobeltiosis and standards heterosis ranged from-9.21 to 20.43% and 10.34 to 37.67%, respectively. The significant positive heterobeltiosis were recorded in five hybrids, whereas nine hybrids showed superiority over standard check for grains panicle^{-1}. Similar results were also reported by Vishwakarma *et al.* (1999) and Seetharamaiah *et al.* (1999). Some of the superior hybrids for grain panicle^{-1} were included IR68891Ax PB-6-1-60-9, IR68891 Ax Gopal Bhog, IR68891 AxPB-5-14-50-1 and IR68888AxPB-5-14-50-1. On the basis of mean performance, some hybrids *viz.,* IR68891 AxPB-6-1-60-9, IR68891 Ax Gopal Bhog and IR68891 AxPB-5-14-50-1 showed maximum grains panicle^{-1}. Test weight is also important yield component, for which heterobeltiosis and standard heterosis in rice hybrids ranged from-9.32 to 25.68% and -11.51 to 27.77%, respectively. These findings are in conformity with earlier results of Singh (1994). Four hybrids exhibited significant positive heterobeltiosis as well as standard heterosis for

Table 1. Mean, heterobeltiosis and standard heterosis of rice hybrids for different yield and quality characters

Cross		DM	PH	NPP	PL	GP	TW	GYP	HRR	KL	KB	L/B	KE	AKD	WUP	BE	GC	AC	OC (%)
IR68888-	Mean	133.67	105.17	15.30	24.60	92.90	1.95	27.66	58.92	7.95	1.89	4.20	1.89	4.55	329.90	4.40	54.60	22.15	26.45
Ax Hawn	BP	2.82	49.81**	74.54*	-2.38	9.14	-9.32**	77.19**	16.36	2.84	-10.86**	-3.23	1.06	-22.41**	34.56**	2.32	24.02**	-2.29	
Kikwai	SV	-4.30	15.07	60.00	-12.36*	18.64*	-1.51**	85.88**	18.03**	2.97	10.53*	-7.09*	-2.57	-35.71**	-12.95*	25.71*	33.17**	-7.70	
IR68888-	Mean	128.00	109.13	9.70	27.90	92.90	2.40	21.54	54.86	7.65	2.08	3.67	1.97	5.36	346.83	4.62	58.83	24.62	29.75
Ax Gopal	BP	-1.53	55.46**	-19.42*	27.36**	-0.95	24.35**	12.83	-8.41	17.51**	-1.90	18.01**	5.34	-8.62	-2.03	-3.76	78.18**	6.12.	
Bhog	SV	-8.35	19.40*	1.97	-0.50	18.64	21.21**	44.75**	9.93	-0.91	21.64**	-18.81**	1.54	-24.28**	-8.49	31.42**	43.41**	2.50	
IR 68888-	Mean	123.40	84.80	13.40	27.50	99.80	2.26	29.48	61.34	7.57	1.94	3.90	1.93	3.22	260.68	3.69	35.00	22.67	44.67
Ax PB-6-	BP	-5.07	20.80**	34.40**	8.69	13.53*	9.16	64.14**	2.85	-0.39	-8.50*	-3.23	-2.91	-44.82**	-25.51**	-26.0**	9.38	-14.45*	
8-48-59-2	SV	-11.64*	-7.22	39.58**	-1.92	27.45*	14.14	98.11**	22.84**	-1.94	13.45**	-13.72**	-0.51	-54.28**	-31.21**	-5.71	-14.63	-5.54	
IR68888-	Mean	130.60	79.60	13.80	21.40	98.90	2.25	30.46	61.79	7.50	1.92	3.90	1.93	5.11	344.58	5.60	40.00	26.53	38.72
Ax PB-6	BP	0.52	13.49	24.68**	-14.06**	19.58*	0.45	52.37**	4.22	3.59	-9.45*	8.03*	-2.03	-12.06*	-10.49	14.28*	14.29**	14.22*	
12-24-4	SV	-6.44	-12.83	44.16**	-23.76**	26.30**	13.63*	104.70**	23.64**	-2.85	12.28*	-13.72**	-5.15	-27.14**	-9.07	60.00**	-2.44	10.41*	
IR68888	Mean	123.30	94.20	12.90	23.80	86.40	2.16	23.28	53.68	7.16	2.50	3.56	1.89	4.50	225.58	3.40	58.23	17.98	28.94
Ax PB-6-	BP	-1.61	34.29**	46.93**	12.80	-9.21	6.74	69.06**	-17.79**	-7.13	-5.66	-21.42**	-4.06	-22.41*	-34.70**	-2.85	-14.41**	-20.44**	
1-60 9	SV	-11.72*	3.14	34.68**	-15.21*	10.34	9.09	56.45**	7.41	-7.25	16.19**	-21.25**	-2.97	-35.71**	-40.47**	-2.85	41.95**	-25.08**	
IR68888	Mean	125.60	73.87	12.60	20.53	102.40	2.09	26.50	66.78	6.65	2.04	3.25	1.80	5.90	335.63	5.40	71.00	21.09	20.76
AxPB-5-	BP	-3.38	5.23	2.35	-5.96	11.79*	7.73	26.49**	12.47**	-7.25	-3.80	-23.35**	-7.69	1.72	19.55*	45.94**	97.22**	-6.68	
14-50-1	SV	-10.07*	-19.18*	31.32**	-26.86**	30.77**	5.55	78.09**	33.66**	-13.86**	19.28**	-28.10**	-7.21*	-15.71*	-11.45**	54.28**	73.13**	-12.12*	
IR68891	Mean	129.00	105.27	9.70	23.80	88.00	2.12	17.63	58.76	6.55	2.13	3.07	1.88	4.83	382.73	4.60	35.62	26.32	29.70
Ax Hawn	BP	-1.28	54.35**	11.25	-5.56	-3.97	-1.40	11.72	15.32**	-15.27**	2.40	-29.26**	-5.34	-7.69	16.03*	-6.79	-58.60**	16.37*	
Kikwai	SV	-7.64	15.18	1.97	-15.21*	12.38	7.07	18.48*	17.63**	-15.16**	24.56**	-32.08**	-3.09	-31.42*	-25.14**	31.42**	-13.17*	9.58*	
IR 68891	Mean	134.00	111.93	11.20	26.67	105.90	2.45	28.20	64.57	6.70	2.11	3.17	1.84	5.27	265.52	3.40	38.00	23.22	42.93
Ax Gopal	BP	3.06	64.12**	-7.16	21.61**	12.89*	25.68**	47.72**	7.67	2.92	1.44	1.93	-1.60	0.00	-25.00**	-27.65**	-58.81	0.08	
Bhog	SV	-3.58	22.46	17.50	-4.99	35.24	23.73	89.51	29.25	-13.21	23.39**	-29.87	-5.15	-25.71**	-29.94**	-2.85	-7.32	-3.25	
IR68891	Mean	131.67	117.80	12.00	27.33	97.70	2.53	29.00	59.92	6.95	2.06	3.37	1.85	5.66	300.40	4.48	47.00	24.86	31.35
Ax PB-	BP	0.77	72.73**	21.16**	7.89	11.14	22.22**	61.64**	0.50	-0.55**	-0.97	-16.38**	-6.56	7.69	-14.17*	-10.00	-47.66**	-6.18	
8-48-59-2	SV	-5.73	28.88**	25.83**	-2.64	24.77**	27.77**	94.89**	20.04**	-9.97**	20.47**	-25.44**	-4.03	-20.00**	-20.73**	28.57**	9.76	3.58	
IR68891	Mean	122.50	108.20	12.80	26.93	99.60	2.25	28.18	56.78	6.91	2.01	3.43	1.90	5.56	280.00	3.91	54.56	20.98	30.72
Ax PB-6-	BP	-6.40	58.65**	15.31**	8.15	20.43*	0.45	40.97**	-4.05	-4.56	-3.37	-4.99	-3.55	5.76	-27.27**	20.40**	-36.91**	-9.64	
12-24-4	SV	-12.29*	18.38*	33.33**	-4.06	27.20**	13.63*	89.38**	13.82**	-10.49**	17.54**	-24.12**	-2.06	-21.42**	-26.12**	11.42	33.17**	-12.58*	
IR68891	Mean	133.00	94.07	12.40	25.73	107.80	2.29	29.87	58.24	6.74	1.85	3.64	1.89	3.89	278.48	3.79	45.00	23.88	29.34
Ax PB-6	BP	6.12	37.93**	41.36**	21.94**	13.03	17.47*	89.29**	-10.73*	-12.58**	-11.07**	-19.65**	-4.06	-26.92**	-19.39*	8.57	-47.67**	16.48*	
1-60-9	SV	-4.78	2.92	29.58**	-8.34	37.67**	15.65*	100.73**	16.63**	-12.69**	8.17	-19.47**	-2.57	-45.71**	-26.51**	5.87	9.76	-0.50	
IR68891	Mean	134.33	107.60	14.40	29.80	104.50	2.13	25.27	57.76	7.08	2.07	3.42	1.92	3.84	360.00	5.41	62.67	24.57	17.87
Ax PB-5-	BP	2.80	57.77**	17.53**	27.35**	14.08	9.25	20.62**	-2.52	-1.25	-0.48	-19.34**	-1.53	-25.02**	28.25**	45.94**	45.94**	19.85*	
14-50-1	SV	-3.82	17.72**	60.83**	-0.96	33.46**	7.57	69.82**	15.83**	-8.29*	21.05**	-24.34**	-1.03	-44.28**	-5.01	54.28**	52.68**	2.37	
SE (+)		1.28	4.00	0.491	2.18	1.97	0.047	1.11	1.087	0.130	0.047	0.096	0.062	0.239	18.01	4.225	3.37	0.415	

*and **significant at P=0.05 and 0.01, respevtively. OC (%) =Out Crossing.

test weight which included IR68888Ax Gopal Bhog, IR68891Ax Gopal Bhog, IR68891Ax PB-8-48-59-2 and 18.48 to 104.7%, respectively. Similar findings were also reported by Sarma and Roy (1996) and Yolanda and Das (1995). Some of the promising hybrids which showed higher degree of heterobeltiosis and standard heterosis included IR68888Ax PB-6-12-24-4, IR68891 Ax PB-6-1-60-9, IR68888AxPB-8-48-59-2, IR 68891 Ax PB-8-48-59-2, IR68891Ax Gopal Bhog and IR 68891 AxPB-6-12-24-4.

Head rice recovery is the major quality component, the heterobeltiosis and standard heterosis for this character ranged from-2.52 to 16.63% and 7.41 to 33.66%, respectively. Three hybrids commonly showed significant positive heterobeltiosis and standards heterosis for head rice recovery. On the basis of mean performance, four hybrids showed maximum head rice recovery included IR68888AxPB-5-14-50-1, IR68891Ax Gopal Bhog and IR68888Ax PB-6-12-24 and IR68888Ax PB-8-48-59-2. The kernel size and shape is the most important quality character which increase market acceptance of rice due to its extra long slender grains and much preferred by the consumers in domestic as well as international market. The hybrids showed significant positive as well as negative heterobbeltiosis for kernel. Vivekanandan and Giridharan (1996) also reported similar results. One hybrid IR68888Ax Gopal Bhog showed significant positive heteobeltiosis whereas some hybrids namely, IR 68891Ax Hawn Kikwai, IR68891Ax PB-8-48-59-2 and IR 68891AxPB-6-1-60-9 were nearly at par with standard check for kernel length. On the basis of mean value, three hybrids viz., IR 68888Ax Hawn Kikwai, IR 68888Ax Gopal Bhog and IR68888Ax PB-8-48-59-2 have extra long grains which can be useful for export purposes if have other desirable quality characters. For kernel breadth, most of the hybrids showed significant negative heterobeltiosis whereas positive standard heterosis were observed in hybrids. The significant positive standard heterosis for kernel breadth had also reported by Geetha *et al.* (1994). The significant negative heterobeltiosis for kernel breadth were observed in IR68888AxHawn Kikwai, IR68888Ax PB-8-48-59-2 and IR68888Axs PB-6-12-24-4. Four hybrids *viz.*, IR68891Ax PB6-1-60-9, IR68888Ax Hawn Kikwai, IR68888Ax PB6-12-24-4 and IR68891Ax PB-8-48-59-2 have fine grains among all of them. Kernel L/B ratio is important quality character and slender grains (>3.0) are much preferred by the consumers. Hybrids showed significant positive as well as negative heterobeltiosis for this character, whereas only negative standard heterosis were observed in hybrids. These findings are contradictory to earlier results of Vivekkanadan and Giridharan (1996) who reported significant negative heterobeltiosis only in rice hybrids. Out of 12, two hybrids, IR68888Ax Gopal Bhog and IR68888Ax PB-612-24-4 exhibited positive heterobeltiosis for L/B ratio. The hybrids showed non-singificant postitive as well as negative heterobeltiosis and standard heterosis for kernel elongation except one hybrid, IR68888Ax PB-5-14-50-1 which showed very little significant negative standard heterosis. Whereas, Vivekandan and Giridharan (1996) reported signigicant negative heterobeltiosis for kernel elongation. On the basis of per se performance, four hybrids were indentified superior among all of them. The significant negative heterobeltiosis and standard heterosis for alkali digestion value were observed in hybrids. These findings are contradictroy with the results of Kaw and Dela Cruz (1991) who reported significant postitive as well as negative heterobeltiosis for alkali digestion value. Some hybrids *viz.*, IR68888AxHawn Kikwai, IR68888AxPB-6-1-60-9 and IR68891Ax Hawn Kikwai showed intermediate alkali digestion value which is desirable for qulality point of view. For water uptake number, four hybrids exhibited significant positive heterobeltiosis, whereas negative standard heterosis were recorded in hybrids. The higher water uptake number were observed in IR68891AxHawn Kikwai, IR68891AxPB-5-14-50-1, IR68888Ax Gopal Bhog and IR68888Ax PB-6-12-24-4. The hybrids showed significant positive as well as negative heterbeltiosis for volume expansion, whereas positive standard heterosis were observed in most of the hybrids. Some of the pormising hybrids for volume expansion included IR68888Ax Gopal Bhog. The gel consistency and amylose content both are important cooking quality charactrers. Most of the hybrids showed significant positive as well as negative heterobeltiosis and standard heterosis for gel consistencey. Kaw and Data Cruz (1991) also reported significant positive as well as negative heterobelitiosis, whereas significant postive standard heterosis for gel consistency were recorded in IR68888Ax PB-5-50-1, IR68891Ax PB-5-14-50-1, IR68888Ax Gopal Bhog and IR68888Ax PB-6-1-60-9. On the basis of *per se* performance, two hybrids, IR68888Ax PB-5-14-50-1 and IR68891Ax PB-5-14-501 have soft gel. For amylose content, four self hybrids IR68891AxPB-5-14-50-1, IR68891AxPB-6-1-60-9, IR 68891 Ax Hawn Kikwai and IR68888Ax PB-6-12-24-4 showed significant positive heterobeltiosis, whereas significant positive standard heterosis were recorded in IR68888AxPB-6-12-24-4 and IR688891Ax Hawn Kikwai. Similar findings were also reported by Holanda and Das (1996). Seven hybrids were identified superior as per se performance for amylose content among all of them. Aroma was tested in all the hybrids but they are all non-aromatic. Overall, three hybrids *viz.*, IR68888Ax PB-6-12-24-4, IR68888AxPB-5-14-50-1 and IR68888Ax Hawn Kikwai were indentified superior over standard check for most of the yield and quality chareacters, whereas three hybrids namely IR68888Ax PB-8-48-59-2, IR68888AxPB-612-24-4 and IR68888AxPB-5-14-50-1 were found to be superior among all of them for their *per se* performace of various yield and quality characthers. The higher outcrossing potential were recorded in three hybrida *viz.*, IR68888Ax PB-8-48-59-2, IR68891Ax Gopal Bhog and IR68888Ax PB-6-12-24-4 which can be useful for exploitatrson of heterosis on the commercial scale. Individually both the CMS line showed from 30.3 to 31.5% outcrossing when interplanted with different testers. Two hybrids, IR68888AxPB-6-12-24-4 and IR68891Ax PB-8-48-59-2 were identified superior among them for their high heterosis as well as high out crossing potential which can be exploited successfully in hybrid rice breeding programme.

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INHERITANCE OF FERTILITY RESTORATION OF FIVE SOURCES OF CYTOPLASMIC MALE STERILITY IN RICE (*ORYZA SATIVA* L.)

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ABSTRACT

The cross combinations involving six male sterile lines of five different cytosterile sources viz., IR 58025 A and PMS 2 A (WA), IR 68885 A (Mutant-induced by gamma irradiation of IR 62829 B), IR 54755 A (ARC), G 46 A (Gambiaca) and D 297 A (Dissi), when crossed with five common restores viz., Ratnagiri 3, Swarna, IR 5, IR46 and IR 54, showed more than 80% spikelet fertility restoration in all the combinations except IR 54755 A x Swarna and IR 54755 A x IR 54. The F_2 segregation classification based on pollen as well as spikelet fertility in the 28 cross combinations, indicated the presence of two independent dominant fertility-restoring genes. The mode of action of the two genes varied in different crosses revealing three types of interaction viz., epistasis with dominance, epistasis with incomplete dominance and epistasis with recessive. Change in fertility restoration by same restorer with CMS line of same source and different source could be due to the influence of female parent genotype or fertility restoring genes has different penetrance and is affected by modifier.

Key words : Cytoplasmic male sterility, fertility restoration, inheritance, *Oryza sativa*.

Since rice is a strictly self-pollinated crop, successful hybrid-breeding programme should involve a highly stable cytoplasmic genetic male sterile line and a good restorer. Restorer lines vary in their ability for fertility restoration (Varmani *et al.* 1985). Precise understanding of genetics of fertility restoration is useful in planning a sound breeding stategy for development of superior restorers in hybrid-breeding programme. It may also help in the efficient transfer of restorer genes into other agronomically desirable genotypes. In rice, several sources of cytoplasmic genetic male sterility (CMS) have been reported (Virmani and Wan, 1988). However, intensive research work on identification of restorers and maintainers and on inheritance of fertility restoration has been done mostly on the WA (Wild abortive) cytoplasmic source but very meagre in other sources.

Therefore, the present investigation was undertaken to determine the genetic control of fertility restoration of five different cytosterile sources viz., Wild abortive, Mutant, ARC, Gambiaca and Dissi.

MATERIALS AND METHODS

The experiment was conducted at Agricultural Research Station, Shirgon (Ratnagiri) during 97-98 *Rabi, 98-99 Kharif and 99-2000 Kharif seasons.* Six male sterile lines of five different sources viz., IR 58025A and PMS 2A (WA), IR 68885A (Mutant-induced by gamma irradiation of IR 62829B), IR 54755 A (ARC), G 46 A (Gambiaca) and D 297 A (Dissi) and five common effective restorers identified for all above CMS lines based on spikelet and pollen fertility of the F_1's during 97-98 *Kharif* season, constituted the material of the present study. Each CMS line was crossed to each restorer during 1997-98 *Rabi* season to obtain 30 cross combinations. Of 30 cross combinations, 28 which had more than 80% pollen and spikelet fertility were selected and these were selfed during 98-99 *Kharif* season to generate F2 population to study the inheritance of fertility restoration.

Twentyfive days old seedlings of F_2's and parental lines were planted the main field by single seedling per hill at a spacing of 20 x 15 cm during 1999-2000 *kharif* season. The 28 crosses were grown along with their parental lines in eight rows each of 7.5-meter length in three groups/ tiers. Recommended agronomic practices were followed while raising the crop. Plant protection measures were carried out as and when required. At the boot leaf stage, 2.5-m high double polythene barriers were erected on all the side of the experimental area, to protect butter bags, which were covered on panicle from wind blow.

To determine the pollen fertility, ten spikelets from middle to top portion of the every two panicles of each of the individual plant in all the population of the crosses excluding border lines, were collected in a vial containing 70% alcohol, care was taken to see the spikelets were matured but not opened. Later the two or three anthers were removed carefully from the spikelets, crushed well, stained with 1% iodine potassium iodide (I+KI) solution and observed under the microscope. They were classified on the basis of pollen fertility into four categories (Govinda Raj and Virmani, 1988).

In order to estimate the spikelet fertility, the main panicles of all the plants excluding borderline in each segregating family of 28 crosses were bagged with butter paper bags prior to anthesis. At the time of maturity, the bagged panicles were harvested and the filled grains and chaffy grains were counted and the fertility percentage was calculated. They were classified on the basis of spikelet fertility percentage into four categories (Govinda Raj and Virmani, 19888). Chi-square analysis was employed to test the goodness of fit of the genetic hypothesis.

RESULTS AND DISCUSSION

Pollen fertility ranged from 80.2 to 97.5%, while spikelet fertility between 78.7 and 91.6%. All cross combinations except IR 54755 A X Swarna and IR 547755 A X IR54 showed more than 80% pollen and spikelet fertility percentage (Table 1). Hence, these 28 cross combinations were meant to study the nature of inheritance of fertility restoration.

The restoration of normal fertility (>80%) in the F1 hybrids indicated the presence of genes necessary for restoration in all the five pollinator varieties and hence indicating fertility restoration is under dominant gene control. Four classes of plant *viz.*, completely sterile (CS), partially sterile (PS) plus partially fertile (PF) and fertile (F) were identified in the segregating population (Table 2). The segregation of fertility and sterility into four classes suggested that relatively few genes were involved in fertility restoration in the CMS lines by the restorers included in the present study. The analysis on number and nature of genes controlling the fertility restoration using both pollen as well as spikelet fertility analysis in F_2 showed fertility restoration in all the lines governed by two independent dominant genes. The mode of interaction of the genes, however, varied among crosses (Table 2).

In case of WA cytosterile source, crosses involving IR 58025 A with Swarna, IR 5 and IR 46 and PMS 2 A with Swarna, IR 5 and IR 46, in case of ARC source, crosses involving IR 54755 A with Ratnagiri 3 and IR 46, in case of Gambiaca source, cross involving G 46 A with Ratnagiri 3 segregated in the ratio of 12 FF: 3 PF plus PS: 1 CS plants (Table 2). Thus, the results indicated the involvement of two dominant genes in the inheritance of fertility restoration, which exhibited epistasis with dominant interaction. In this case, one of the dominant genes was epistatic to the other dominate gene for fertility restoration ability. These results have also been confirmed on the studies of earlier workers *viz.*, Singh and Sinha (1983); Govinda Raj and Virmani (1988); Ramalingam *et al.* (1992); Singh *et al.*, (1994); Kumari *et al.* (1998); Pradhan and Jachuck (1999) and Sohu and Phul (1995) who reported an epistasis with dominant fertility restoring genes in the inheritance of fertility restoration WA and Gambiaca CMS system, respectively.

In case of the F2 progenies of WA cytosterile source, crosses involving IR 58025 A with Ratnagiri 3 and IR 54 and PMS 2 A with Ratnagiri 3 and IR 54, segregated in the ratio of 9:6:1 revealing the role of two dominant independent genes in the inheritance of fertility restoration and displayed epistasis with incomplete dominance interaction. This indicated that two dominant genes are responsible for complete fertility, while only one of the either gene conferred partial fertility (semi-epistatic type of gene interaction). These results are in accordance with the earlier reports of WA CMS lines (Singh and Sinha, 1988; Govinda Raj and Virmani, 1988; Ramlingam *et al.*, 1995; Sohu and Phul, 1995; Ganesan and Rangaswamy, 1997; Kumari *et al.*, 1998; Pradhan and Jachuck, 1999).

However, the F_2 population of the crosses involving CMS line PMS 2A of WA source with Ratnagiri 3, in case of ARC source, crosses involving IR 54755 A with IR 5, in case of Gambiaca source, crosses involving D 297 A with all five restorers, single recessive gene was epistatic over the other dominant gene for fertility restoration, making the individual plants sterile like the double recessive condition. The other single dominant gene makes the individuals partial fertile, while the presence of both the dominant genes makes the individual plant fertile. Similar results were also reported by Govinda Raj and Virmani (1988); Bharaj *et al.* (1991); Ramalingam *et al.* (1992); Sohu and Phul (1995) in the inheritance of fertility restoration of WA and Gambianca CMS system, respectively.

The interaction of two fertility-restoring genes varied in the crosses involving the same restorers with different CMS lines WA source. When Ratnagiri 3 and IR 46 were crossed with IR 58025 A, the ratio were 9:6:1 and 12:3:1, respectively, whereas with PMS 2A, it showed a ratio of 9:3:4 and 9:6:1 and 12:3:1, respectively (Table 2). The five restorers *viz.*, Ratnagiri 3, Swarna, IR 5, IR 46 and IR 54 were able to restore more than 80% fertility in CMS line of WA, Mutant, ARC and Gambiaca sources, the segregation patterns in the CMS lines of said four cytosteriles were different. The differential gene interaction could presumably be due to the influence of female parent genotype and/or a probable variation expression of the restorer genes in different genetic background (Govinda Raj and Virmani, 1988; Ramlingam *et al.* 1992; Sohu and Phul, 1995; Genesan and Rangaswamy, 1997; Kumari *et al.* 1988; Pradhan and Jachuck, 1999). Certain minor or modifier genes could also be responsible for changing the segregation pattern (Govinda Raj and Virmani, 1988; Ramalingam *et al.*, 1992; Leenakumari *et al.*, 1996; Genesan and Rangawamy, 1997; Kumari *et al.*, 1998). This knowledge on mode of action of fertility restoring genes makes us to sculpture the breeding objectives in hybrid rice technology.

Table 1. Pollen and spikelet fertility in 30 F_1 hybrids of rice

Sr No.	Crosses	Fertility %		Sr. No.	Crosses	Fertility %	
		Pollen	Spikelet			Pollen	Spikelet
1.	IR58025A/Ratnagiri 3	97.4	87.9	16.	IR54755A/Ratnagiri 3	88.9	81.7
2.	IR58025A-Swarna	89.3	86.5	17.	IR54755A/Swarna	80.2	78.7
3.	IR58025A/IR 5	96.9	89.5	18.	IR54755A/IR 5	87.2	82.0
4.	IR58025A/IR 46	95.3	89.4	19.	IR54755A/IR 54	86.0	81.4
5.	IR58025A/IR	97.5	88.1	20.	IR54755A/IR 54	81.7	79.6
6.	PMS 2A/ Ratnagiri 3	97.4	83.9	21.	G 46 A/ Ratnagiri 3	89.4	86.6
7.	PMS 2A/Swarna	89.4	83.9	22.	G 46 A/ Swarna	89.5	84.9
8.	PMS 2A/IR 5	91.4	87.1	23.	G 46 A/ IR 5	97.5	91.2
9.	PMS 2A/IR 46	91.2	87.0	24.	G 46 A/ IR	93.9	86.0
10.	PMS 2A/IR 54	89.0	84.7	25.	G 46 A/ IR	93.6	88.2
11.	IR68885A/Ratnagiri 3	91.7	85.2	26.	D297A/Ratnagiri 3	94.1	88.7
12.	IR68885A/Swarna	84.7	86.7	27.	D297A/Swarna	94.0	87.3
13.	IR68885A/IR	93.7	88.6	28.	D297A/R5	96.5	89.2
14.	IR68885A/IR 46	91.5	85.0	29.	D297A/IR 46	89.0	84.6
15.	IR68885A/IR 54	93.1	86.3	30.	D297A/IR 54	89.4	86.6

Table 2. Segregation pattern for pollen and spikelet fertillity restoration in F_2 population of 28 crosses

Sr. No.	Crosses	F2 Popu-lation	Pollen fertility reaction No. of plants F	PF* PS*	CS	x^2 value	Genetic ratio (Probability)	Spikelet fertility reaction No. of plants F	PF* PS*	CS	x^2 value	Genetic ratio (Probability)
WA source												
1	IR 58025 A/RTN	300	177	74 31 105	18	0.536	9 : 6 : 1 (0.90 < P < 0.75)	189	68 27 95	16	5.421	9 : 6 : 1 (0.90 < P < 0.75)
2	IR 58025 A/Swarna	300	214	41 27 68	18	3.162	12 : 3 : 1 (0.25 < P < 0.10)	220	39 23 62	18	0.807	12 : 3 : 1 (0.75 < P < 0.50)
3	IR 58025 A/IR 5	300	229	33 21 54	17	0.352	12 : 3 : 1 (0.90 < P < 0.75)	234	32 17 49	17	1.445	12 : 3 :1 (0.50 < P < 0.25)
4	IR 58025 A/IR 46	300	230	37 15 52	18	0.450	12 : 3 : 1 (0.90 < P < 0.75)	235	34 13 47	18	1.943	12 : 3 : 1 (0.50 < P < 0.25)
5	IR 58025 A/IR 54	298	173	64 39 103	22	1.761	9 : 6 : 1 (0.50 < P < 0.25)	180	65 31 45	22	4.032	9 : 6 : 1 (0.25 < P < 0.10)
6	PMS 2 A/Swarna	300	210	32 21 53	27	3.640	12 : 3 : 1 (0.25 < P < 0.10)	228	29 16 45	27	5.568	12 : 3 : 1 (0.10 < P < 0.05)
7	PMS 2 A/IR 5	300	210	47 17 64	26	4.772	12 : 3 : 1 (0.10 < P < 0.05)	216	45 13 58	26	3.010	12 : 3 : 1 (0.50 < P < 0.25)
8	PMS 2 A/IR	300	156	78 39 117	27	4.591	9 : 6 : 1 (0.25 < P < 0.10)	164	75 34 109	27	3.596	9 : 6 : 1 (0.50 < P < 0.25)
9	PMS 2 A/IR	300	156	89 31 120	24	2.887	9 : 6 : 1 (0.25 < P < 0.10)	166	83 23 110	24	1.405	9 : 6 : 1 (0.50 < P < 0.25)
10	PMS 2 A/RTN	300	162	22 31 53	85	1.784	9 : 3 : 4 (0.25 < P < 0.10)	170	16 29 45	85	3.500	9 : 6 : 1 (0.25 < P < 0.10)
Mutant source-Induced by gamma irradiation of IR 6282 B												
11	IR 68885 A/RTN 3	300	170	72 36 108	22	0.623	9 : 6 : 1 (0.75 < P < 0.50)	177	70 31 101	22	1.933	9 : 6 : 1 (0.50 < P < 0.25)
12	IR 68885 A/Swarna	300	228	36 19 55	17	0.269	12 : 6 : 1 (0.90 < P < 0.75)	236	32 15 47	17	2.195	12 : 6 : 1 (0.50 < P < 0.25)
13	IR 68885 A/IR 5	300	225	38 20 58	17	0.281	12 : 3 : 1 (0.25 < P < 0.10)	234	35 14 49	17	1.445	12 : 3 : 1 (0.50 < P < 0.25)
14	IR 68885 A/IR 46	300	218	47 21 68	14	4.105	12 : 3 : 1 (0.25 < P < 0.10)	225	44 17 61	14	1.762	12 : 3 : 1 (0.50 < P < 0.25)
15	IR 68885 A/IR 54	300	171	78 35 113	16	0.507	9 : 6 : 1 (0.90 < P < 0.75)	179	74 31 105	16	1.507	9 : 6 : 1 (0.50 < P < 0.25)
ARC source												
16	IR 54755 A/RTN 3	300	220	45 15 60	20	0.450	12 : 3 : 1 (0.90 < P < 0.75)	231	38 11 49	20	1.088	12 : 3 : 1 (0.75 < P < 0.50)

Sr. No.	Crosses	F2 Popu-lation	Pollen fertility reaction No. of plants				x^2 value	Genetic ratio (Probability)	Spikelet fertility reaction No. of plants				x^2 value	Genetic ratio (Probability)
			F	PF*	PS*	CS			F	PF*	PS*	CS		
WA source														
17	IR 54755 A/IR 5	300	181	14	35	70	2.060	9 : 3 : 4	168	11	33	68	5.360	9 : 3 : 1
				49				(0.50 < P < 0.25)		44				(0.10 < P < 0.05)
18	IR 54755 A/IR 46	300	221	38	17	24	1.405	12 : 3 : 1	232	33	11	24	4.105	12 : 3 : 1
				55				(0.50 < P < 0.25)		44				(0.25 < P < 0.10)
Gambliaca source														
19	IR 46 A/ RNT 3	300	210	39	27	24	4.102	12 : 3 : 1	217	35	24	24	1.761	12 : 3 : 1
				66				(0.25 < P < 0.10)		59				(0.50 < P < 0.25)
20	G 46 A/ Swarna	300	163	18	35	84	1.451	9 : 3 : 4	170	15	31	84	2.872	9 : 3 : 4
				53				(0.50 < P < 0.25)		46				(0.25 < P < 0.10)
21	G 46 A/IR 5	300	171	23	37	69	0.790	9 : 3 : 4	178	19	34	69	1.120	9 : 3 : 4
				60				(0.75 < P < 0.50)		53				(0.75 < P < 0.50)
22	G 46 A/ IR 5	300	153	17	51	74	4.091	9 : 3 : 4	160	22	31	72	1.435	9 : 3 : 4
				68				(0.25 < P < 0.10)		63				(0.50 < P < 0.25)
23	G 46 A/ IR 54	300	174	21	39	66	1.514	9 : 3 : 4	183	17	34	66	2.686	9 : 3 : 4
				60				(0.50 < P < 0.25)		51				(0.50 < P < 0.25)
Dissi source														
24	D 297 A/RTN 3	300	154	21	41	84	3.054	9 : 3 : 4	163	20	35	82	0.884	9 : 3 : 4
				62				(0.25 < P < 0.10)		55				(0.75 < P < 0.50)
25	D 297 A/ Swarma	300	159	23	44	47	2.766	9 : 3 : 4	167	20	39	74	0.198	9 : 3 : 4
				67				(0.50 < P < 0.25)		59				(0.95 < P < 0.90)
26	D 297 A/ IR 5	300	159	21	38	82	1.406	9 : 3 : 4	168	18	32	82	1.302	9 : 3 : 4
				59				(0.50 < P < 0.25)		50				(0.75 < P < 0.50)
27	D 297 A/IR 46	300	154	25	39	82	3.127	9 : 3 : 4	161	25	35	82	1.050	9 : 3 : 4
				64				(0.25 < P < 0.10)		57				(0.75 < P < 0.50)
28	D 297 A/IR 54	300	181	19	39	61	3.536	9 : 3 : 4	187	14	38	61	4.816	9 : 3 : 4
				58				(0.25 < P < 0.10)		52				(0.10 < P < 0.05)

F=Fertile PF=Patially fertile, PS=Partially sterile, CS=Completely sterile
Pollen fertility : F=60-100%; PF=30-60%; PS=1-30%; CS=0%
Spikelet fertility : F=80-100%; PF=30-80%; PS=1-30%; CS=0%

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CONFLICTS AND CONFLICT MANAGEMENT STYLES OF SELF HELP GROUPS OF FARM WOMEN

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Abstract

A study was undertaken in 2003 to identify the different conflicts arising in self help groups and confliet management styles adopted by each group. The results revealed that most of the conflicts were centered around labour contribution and monetary aspects. The study also identifies arbitration and negotiation as the conflict management styles adopted by the groups with high functional effectiveness.

Key words : Confliet management, farm women, salf help groups.

The realization of the strength in community organisation like self help groups in uplifting the under privileged sections of the society has led to the mushrooming of such groups all over the country. Unfortunately, many such self help groups (SHGs) after their initial impetus fail to sustain; the major culprit behind the same in nothing, but conflicts. The present study is an attempt to unravel the different conflict management styles adopted by women SHGs.

The study was conducted in Thrissur and Ernakulam districts of Kerala State.

Materials And Methods

Three agriculture oriented Non-Governmental Organisations (NGOs) functioning in the above mentioned districts were randomly selected and two exclusive women self help groups; each comprising of fifteen members were randomly selected from each of these NGOs. Thus sample for the study was constituted by ninety self help group members.

Data was collected in the year 2003 and, the techniques used for data collection were structured interview schedule, focused group discussions, non-participant observation.

The different conflicts encountered by the group have been identified using open ended questions. The responses were content analysed and prioritized on the basis of frequencies.

The instrument used to identify the conflict management style was the opinion survey of organizational conflicts (OSOC) developed by Pareek (1997). According to him, the general conflict management orientation may be an avoidance-orientation or an approach orientation. The tool delineates eight different management styles ;

A. Avoidance styles

Avoidance styles of conflict management aim at avoiding or postponing conflicts in a variety of ways. There are four main avoidance styles.

(i) *Resignation* : The extreme avoidance mode is fatalistic ; regarding conflicts with a view of helplessness. Conflicts are seen as a part of reality, arising out of the unreasonable stand of an out-group, usually hostile. Another form of resignation is to ignore the conflicts.

(ii) *Withdrawl* : This form of avoidance is to get away from a conflict situation. This may be done by avoiding situations of potential conflicts. Withdrawing from a conflict, physical separation or by defining the boundaries of interaction with the out group.

(iii) *Defusion* : The main objective of this style is to buy time for dealing with a conflict. It may take several forms like the 'cool down' approach, passage of time, appealing of good sense and developing a temporary arrangement of interaction with the out group.

(iv) *Appeasement* : The main objective is to buy temporary peace. It provides certain concessions in the hope that the outgroup will be satisfied and conflict will be over.

B Approach styles

Approach modes or styles may take more aggressive or understanding forms by taking positive steps to confront conflicts and find solutions. There are four approaches.

(I) *Confrontation* : When the in group perceives the outgroup to be both opposed to its interests and unreasonable, this mode of confrontation may be adopted Confrontation is fighting out an issue to get a solution in one's favour.

(II) *Compromise* : If the out group is seen as being interested in peace, an attempt may be made to seek a compromise. This is a process of sharing in the gain, without resolving the conflict. This may be done by bargaining.

(III) *Arbitration* : If the out group is perceived as being belligerent and not interested in peace, and yet not totally unreasonable, arbitration by a third party may be sought to access this situation objectively and give an 'award' acceptable to both groups.

(IV) *Negotiation* : Here both the factions jointly confront the problem and explore its solution.

OSOC contains twenty four statements; three for each of the eight styles of conflict management; four avoidance styles and four approach styles. The respondent was asked to read each statement and indicate how strongly she agreed with it using a five point scale with scores of 1, 2, 3, 4 and 5 for strongly disagree, half agree, and strongly agree dimensions of the continuum respectively.

The recorded answer sheet were scored to get scores of group members for each style. The total scores on each style ranged from 3 to 15. The scores of the members of a SHG for each style was averaged to get the score of that SHG for different management styles.

RESULTS AND DISCUSSION

The different conflicts that hampered the smooth functioning of the groups as revealed by the members given in Table 1.

As cited by 66.7 percent of the respondent, one of the major reasons behind the conflict was regarding the division of labour while executing the group activities. Another factor which triggered conflicts as indicted by 51.11 per cent of the respondents was regarding the profit sharing especially under the situations of unequal contribution of labour. According to 31 percent of the respondents leniency shown by leader towards some members, if not extended to other members would be treated as personal bias and ended up in conflicts. Another major conflict as perceived by 28.88 per cent of the respondents was over the defaults in the repayment of the loans provided to the members. About 33.3 percent of the respondents revealed that conflicts were common over the issue of consistent absenteeism of the members in SHG meeting.

Conflict management styles adopted by each

Table 1. Major conflicts in the SHGs

Sl. No.	Conflicts	No. of respondents	Percentage
1.	Division of labour	60	66.7
2.	Sharing of unequal labour contribution	46	51.1
3.	Leviency shown towards some members	28	31.0
4.	Default in loan payment	26	28.9
5.	Consistent absentecism of some members	12	13.3

Table 2. Distribution of groups based on conflict management styles

Sl. No.	Conflict managed style	Group I	Group II	Group III	Group IV	Group V	Group VI
A.	Approach styles						
1.	Resignation	8.08	7.63	8.42	8.08	8.08	11.50
2.	Withdrawal	9.40	8.32	9.64	7.60	10.10	10.60
3.	Defusion	8.60	9.60	8.18	9.20	8.76	10.60
4.	Appeasement	9.30	9.16	9.26	9.16	9.36	8.96

Scores ranging from 3-15

Table 3. Distribution of groups based on conflict management styles

Sl. No.	Conflict managed style	Group I	Group II	Group III	Group IV	Group V	Group VI
B.	Approach styles						
5.	Confrontation	6.30	10.00	9.04	12.00	8.96	9.36
6.	Compromise	11.11	11.80	11.00	8.08	10.60	9.12
7.	Arbitration	12.00	13.00	10.80	11.00	10.60	9.16
8.	Negotiation	10.20	11.50	11.80	12.00	11.50	9.26

Scores ranging from 3-15

group as identified using OSOC was revealed in the results (Tables 2 and 3).

The groups I and II indicated high value for arbitration which implied the involvement of third party for conflict resolution. Interestingly, these two SHGs had high level of functioning effectiveness and both were formed under same NGO. From the focused group discussion researcher had with the SHG members, it came out that officials of NGO to which these SHGs were affiliated, constantly monitored the functioning of the groups and made timely interventions to resolve the conflicts.

The group III and IV also possessing high levels of functioning effectiveness resorted to negotiation wherein, conflicting factions with the group jointly confronted the problem and explored its solutions.

Negotiation was the style adopted by most of the members of group V, which possessed relatively low level of functioning effectiveness. The majority of the members of the group VI, ignored the conflicts as indicated by the highest score of the group for resignation. This group also was less effective in functioning.

Conclusion

Thus most of the conflicts that haunted the Self Help Groups were centered around labour and monetary aspects.

Thus the groups with highest functioning effectiveness were adopting arbitration and negotiation as the conflict management strategies which might have positively contributed to their effective functioning.

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EFFECT OF RESOURCE CONSERVING TECHNOLOGIES ON SOIL QUALITY INDICES UNDER RICE-WHEAT CROPPING SYSTEM

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ABSTRACT

The study was undertaken to determine the effect of Resource conserving technologies (RCTs) *viz.*, zero tillage (ZT) and bed planting (BP) over conventional tillage (CT) on different soil quality indicators under the rice-wheat cropping system. Out of 16 soil properties measured, 13 were statistically different ($P<0.05$) under different RCTs. Nutrient availability and microbial indicators were found to be significantly improved under zero tillage and bed planting than the conventional tillage. PLFAs, the environmental stress biomarkers were present in lower amounts under ZT and BP than in CT. Evaluation of soil quality indices (SQI) using minimum data set selection and principal component analysis revealed a higher value of SQI for ZT and BP than CT.

Key words : RCT's, soil quality indices, microbial indicators, PLFA profiles.

Resource conserving technologies such as zero tillage and bed planting are the potential agricultural management practices used to conserve soil moisture, reduce soil erosion besides increasing soil fertility. They have a prominent effect on soil organic matter dynamics, nutrient availability and are known to play a key role on soil quality,

Soil quality evaluation consists of integration of physical, chemical and microbial properties of soil for determining the susceptibility of land management. In addition to soil physical and chemical attributes, the biological components, especially the soil microbial properties are considered as early and sensitive indicators to detect changes in the soil microbial properties are considered as early and sensitive indicators to detect changes in the soil due to land use and anthropogenic practices. They can further be used to assess the temporal trends in the soil quality under different land use practices in order to discern whether they are aggrading, degrading or sustaining the soil quality.

Soil microbial biomass is the driving forces for most of the terrestrial ecosystem and largely controls the rates to turnover and mineralization of organic substrates. It constitutes a transformation matrix for soil organic matter and acts as an active reservoir for plant available nutrients. Unlike soil organic matter, the microbial biomass responds more rapidly to any change in ecosystem condition and acts as valuable tool for understanding and predicting the effect of land use and management practices (Monkiedje *et al.* 2002). Microbial indicators that have been used to determine soil microbial biomass include soil microbial biomass carbon (SMBC), soil microbial biomass nitrogen (SMBN), soil enzymes and soil respiration. On the other hand, phospho lipid fatty acid (PLFA) profiles are the novel tools that enable us to study rapid changes in soil microbial community structure under diverse land management options.

Studies pertaining to the impact of RCTs on soil quality indicators especially PLFA have not been addressed adequately and are very few. Therefore, this study was designed to determine the sensitivity of various soil quality indicators to resource conserving technologies and an

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attempt has been made to compare the soil quality indices under these conservation practices.

MATERIALS AND METHODS

The experimental site was located in the farmer's field at Dasna village in Ghaziabad district of Uttar Pradesh, where the rice-wheat cropping system was followed as a continuous practice. The field was subjected to different resource conserving technologies like zero tillage and bed planting following standard procedures and conventional tillage was considered as the control. Recommended doses of fertilizers were applied to both the rice and the wheat crop during their respective cropping seasons. Soil sampling was carried out on monthly intervals during the year 2003 from 0-15 cm soil depth and was processed for further analysis using standards procedures.

Soil pH and EC were measured on soil: water 1:1 paste and standard methods were used for the determination of organic *biomass*, available N, P and K (Page *et al.* 1982). Soil samples were subjected to chloroform fumigation and soil microbial biomass was extracted with K_2SO_4 as outlined by Witt *et al.* (2000). Soil microbial biomass nitrogen was determined by oxidation with $K_2S_2O_8$ as described by Cabrera and Beare (1993). The phospholipid extraction and analysis of PLFAs was conducted as described by Frostegard *et al.* (1993).

Soil quality index was calculated using the procedure described by Andrews *et al.* (2002). Minimum data set (MDS) of soil quality indicators was selected using the multivariate statistical principal component analysis (PCA) for SQI calculation. Scoring was given to indicators using linear scoring method and weights were assigned to the indicators through PCA using the following equation.

Weightage for the particular indicator =

%variation contributed by the PC to which the indicator belong /Total cumulative % of the PCs used the MDS

Weightage additive soil quality index was prepared using the following equation

$$\text{PCA}-\text{SQI}=\sum_{i=n}^{n} W_i * S_i$$

where W- weights assigned to indicator, S-score of the indicator. It was assumed that higher the value of soil quality index, better is the soil quality.

RESULTS AND DISCUSSION

Impact of RCTs on soil properties

Data pertaining to the effect or RCTs on different soil quality indicators under the rice-wheat cropping system was shown in Table 1. Soil pH and EC were not found to vary significantly among the treatments. The soil organic carbon content did not vary much between the RCTs and CT. The minimal differences among the treatments may be due to the short observation periods, which were not sufficient to influence a change in the organic carbon content of the soil.

RCTs had significantly increased the availability of plant nutrients in soil as compared to CT (Table 1). The available N, P and K registered higher, values in both the conservation techniques (zero tillage and bed planting), where as the conventional tillage depicted lower values. This could be related to increased nutrient mineralization owing to crop residue accumulation as being promoted by RCTs.

The microbial indicators of soil quality *viz.*, soil microbial carbon (SMBC), C_{mic}/C_{org} and soil microbial biomass nitrogen (SMBN) were significantly ($p<0.05$) present in higher concentrations under RCTs as compared to the conventional tillage (Table 1). Emmerling *et al.* (2001) reported 10-15 per cent increase in C_{mic}/C_{org} under the conservation tillage as compared to the conventional management system. Accumulation of crop residues within the surface layer, conducive environment for soil organisms for residue decomposition, reduced water loss and maintenance of temperature fluctuations in addition to the presence of continuous substrate for microbial decompostion are the contributing factors for higher values of microbial indicators

Table 1. Soil quality indicators in rice-wheat system under different conservation practices

Soil quality indicator	Zero tillage	Bed planting	Conventional tillage	Significance level ($p<0.05$)
Available N (kg/ha)	145.10	138.00	110.00	0.0235
Available P (kg/ha)	17.50	18.65	16.90	0.049
Available K (kg/ha)	225.60	213.00	210.40	0.039
SMBC (μg/g)	85.00	85.00	65.1	0.031
SMBN (μg/g)	15.2	43.9	21.6	0.018
Cmic/Corg (%)	2.0	2.0	1.5	0.001
Total PLFA (ηm/g)	524.1	540.0	479.1	0.001
B PLFA (ηm/g)	425.0	432.0	418.0	0.001
F PLFA (ηm/g)	47.3	53.1	24.5	0.001
F:B PLFA (ηm/g)	0.11	0.12	0.06	0.001
Gram-negative bacterial PLFA (ηm/g)	92.58	110.30	132.00	0.001
Gram-positive bacterial PLFA (ηm/g)	164.10	182.30	164.10	0.001
Stress biomarkers (ηm/g)	11.60	8.00	36.20	0.001

B PLFA-Bacterial PLFA, F PLFA-Fungal PLFA

under RCTs. The greater stratification of SMBC under zero tillage was also reported by Jensen *et al.* (1997).

Impact of RCTs on PLFA profiles

Soil microbial community structure studied through PLFA profiles showed a clear shift in microbial groups to RCTs. It was found that the total PLFA content was present in higher concentration under RCTs than in CT. Ibekwe *et al.* (2002) reported that the microbial biomass estimated from extractable PLFA was higher under no till soil than in conventional till soil. PLFAs (i15:0, a15:0, 15:0, 16:0, 16:1ω9, 16:1ω7t, i17:0, 17:0, cy17:0, 18:1ω9, cy19:0) that are biomarkers of bacterial community were present in significantly higher abundance under RCTs as compared to the conventional tillage (Table 1, Fig. 1). Increased obundance of bacterial PLFA could be attributed to increased substrate availability through incorporation of crop residues under RCTs.

In addition to total bacterial PLFA, the different bacterial groups (gram-positive and gram-negative bacteria) also showed variation amongst the RCTs and CT (Table 1). The abundance of gram-positive bacterial PLFA (i15:0, a15:0, i16:0, i17:0) was found to be more under RCTs than in CT. On the other hand, the gram-negative bacterial PLFAs (cy17:0, cy19:0, 16:1ω9, 18:1ω9) were present in more concentration under conventional tillage than in RCTs. These findings gets further support from the previous studies, where increase in gram-negative bacterial PLFA and decrease in gram-positive bacterial PLFA were observed under environmental stress conditions like pesticide application (Zelles *et al.* 1994).

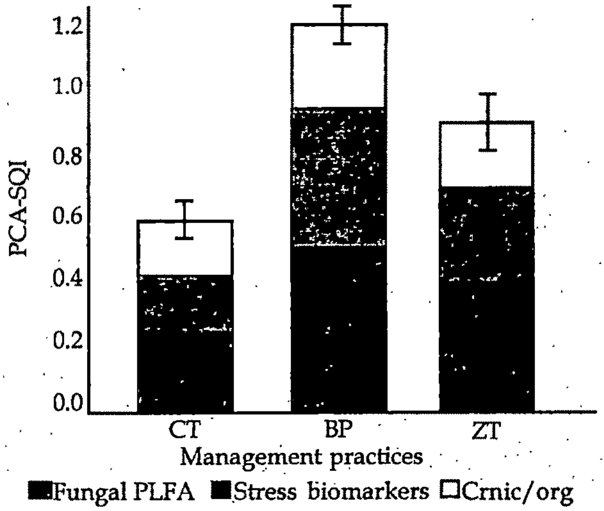

Fig. 1. PCA based soil quality index for different practices

Studies on fungal PLFA revealed that the RCTs had significantly increased the abundance of fungal PLFA (18:2ω6) as compared to the conventional tillage. The fungal : bacterial PLFA was also found in higher concentrations under the RCTs than in the CT (Table 1). Peterson and Klug (1994) reported a decrease in fungal biomarkers due to tillage operations. Similarly, PLFAs cy17:0 and cy19 : 0, which were regarded as environmental stress biomarkers were present in significantly higher concentration under RCTs than in CT (Fig. 1). These findings are in consistence with the previous studies, where increase in stress biomarkers was documented due to tillage operations (Peterson and Klug, 1994).

Evaluation of soil quality index

(a) PCA and minimum data set selection

The soil quality indicators that were significantly varied under different tillage operations were used for principal component analysis (PCA). Principal components which had received the eighen value greater than 1 were opted for the selection of minimum data set. In our study, we observed that two PCs received the eighen value greater than 1 (Table 2). During the analysis, each variable under a particular PC was given a factor loading that represents the contribution of that variable to the compostion of PC. The variables having high factor loadings (which have absolute values within 10% of the highest factor loading) within each PC were used for the minimum data set (MDS) selection.

Table 2. Principal component analysis of soil quality indicators for RCTs

Principal components	PC 1	PC 2	PC 3
Eigen value	6.61	3.44	0.9
Cumulative %	47.2	24.5	8.3
Eigen vectors			
SMBC	0.279	0.321	0.130
Organic carbon	0.021	0.339	0.433
C_{mic}/C_{org}	0.274	**0.447**	-0.015
SMBN	0.197	0.217	0.122
Available N	0.145	0.331	0.9
Available P	0.143	0.341	8.3
Available K	0.267	0.050	0.130
Total PLFA	**0.367**	-0.125	0.433
Bacterial PLFA	0.233	0.157	-0.015
Fungal PLFA	**0.355**	-0.165	0.122
Fungal: Bacterial PLFA	**0.343**	-0.201	-0.126
Gram-negative bacteria	-0.260	0.231	-
Gram-positive bacteria	0.287	-0.293	-
Stress biomarkers	**-0.329**	0.238	-

The highly weighted factor loadings under PCI were total PLFA, fungal PLFA, fungal: bacterial PLFA and stress biomarkers. Correlation coefficients of the variables affirm that all the variables were well correlated (Table 3). Of these variables, fungal PLFA was found to be the most representative of the group because it received the highest correlation sum (Table 3). As the PC1 accounts for 47.2 per cent of variability in the data set, consequently one variable having lowest correlation sum (stress biomarkers) was also selected for the MDS. Similarly in PC2, C_{mic}/C_{org} received the highest factor loading and hence was selected for minimum data set. Thus the final MDS consists of the fungal PLFA, stress biomarkers, C_{mic}/C_{org}.

(b) Scoring and assigning weightage

After scoring of the indicators using linear scoring method, the weightage was assigned to the indicators via PCA using the following equation.

Weightage for the particular indicator =

% variation contributed by the PC to which the indicator belong / Total cumulative % of the PCs used the MDS

The weightage assigned to the MDS for fungal PLFA, stress biomarkes, C_{mic}/C_{org} were 0.47, 0.47 and 0.24, respectively.

(c) Weightage additive index formation

Soil quality index was formed using the following equation.

Table 3. Correlation coefficient sums of highly weighted variables under first principal component

Soil quality indicators	Total PLFA	F PLFA	F:B PLFA	Stress biom-arkers
Total PLFA	1.00	0.94	0.91	-0.88
F PLFA	0.94	1.00	0.99	-0.92
F:B PLFA	0.91	0.99	1.00	-0.93
Stress biomarkers	-0.88	-0.92	-0.93	1.00
Correlation sum	1.98	2.01	1.97	-1.73

$SQI=0.47*S^{F\ PLFA}+0.47*S^{SB}+0.24*S^{Cmic/Corg}$

$S^{F\ PLFA}$ = Score for fungal PLFA

S^{SB}=Score for stress biomarkes

$S^{Cmic/Corg}$=Score for $^{Cmic/Corg}$

Fungal PLFA and stress biomarkers had age received the highest weightage and were selected as key variables of soil quality. The PCA-SQI values (Fig. 1) were highest for BP (1.09) followed by ZT (0.92) and CT had received the lowest value (0.47). Karlen and Stott (1994) observed a higher SQI values for zero tillage than in conventional tillage practices.

The results of this study indicates that resource conserving technologies (zero tillage and bed planting) stimulates soil microbial functions as evidenced by increase in microbial biomass and available nutrients and shifts the soil microbial community having more concentration of fungal PLFAs and less of environment stress biomarkers. It is concluded that RCTs are proposed as sustainable land management options over CT because they have received higher PCA-SQI values.

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STUDIES ON GENETIC VARIABILITY EXPLOITATION FOR QUALITY TRAITS AND AGRONOMIC CHARACTERS ON QUALITY PROTEIN MAIZE (OPM) GERMPLASM (*ZEA MAYS* L.)

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ABSTRACT

The present study was undertaken to identify maize lines having high protein, oil and grain yield at two locations. Per se performance and genetic behaviour for 14 yield and quality parameters were studied in 169 genotypes. The experiment was laid out in simple lattice design (13 x 13 structure) with two replications. The analysis of variance revealed significant variability for all the agronomic and quality parameters and thus helped in selection of specific parents for different characters. Among the fourteen characters studied, the genetic advance as per cent of mean along with higher values of heritability, GCV and PCV estimates was maximum for grain yield per plot and protein yield, indicating that the genetic variance had high addive gene effects. From 169 genotypes evaluated ten best lines were identified for their good agronomic and quality characters, suggesting that, these lines could be utilized in future breeding programme in developing high yield potential QPM hybrids.

Key words : Quality protein maize, genetic variability, heritability, genetic advance, *Zea mays* L.

Maize (*Zea mays* L.) is one of the most important crops in India and has highest yield potential than all other cereals. Several millions of people in the developing world across the globe consume maize as an important staple food and derive their protein and calories requirement. Quality breeding programme in maize for improvement of protein and oil content coupled with higher grain yield grain yield has been recently rejuvenated in India by the introduction of quality protein maize (QPM) and high oil maize (HOM) germplasm from CIMMYT, Mexico. In the present study, newly developed QPM and high oil maize inbreeds with hard endosperm (looking like normal maize kernel type) were evaluated to study the extent of variability existing for protein. Oil and yield components and to identify suitable parents for their future use in hybrid breeding programme.

MATERIALS AND METHODS

A total of 169, S_3-S_4 generation QPM lines (125) and high oil maize lines (44) derived from QPM and high oil maize genepools and population with normal looking endosperm (Hard endosperm) were taken up for studying genetic variability and to indentify superor parents for agronomic, qualityand grain yield characters. All the parental lines including two checks (viz., Shakti-I (QPM composite) and Shaktiman-I (QPM hybrid) were evaluations in sample lattice design with three replications during *kharif* 2001 at two locations namely, Agricultural Research Station (Maize), Amberpet, Hyderabad and College Farm, College of Agriculture. Rajendranagar. Hyderabad. Each plot consisted of 5m long single row spaced 75cm apart. Inter-plant distance with in the row was 20cm. All the usual recommended package of practices were followed for raising a good healthy crop. Data were recorded on agronomic and maturity parameters [viz., days to 50% tasselling, days to 50% silking, days to 50% days to 50% maturity, plant height (cm), ear height (cm), ear length (cm), ear girth (cm), 100-seed weight (g), number of seeed rows per ear, numbr of seeds per row and grain yield per plot (kg)] in addition, the quality parameters like oil content (%), protein (%) and protein yield (kg/ ha). Protein content was determined by multiplying total nitrogen content of grain

Table 1. List of 169 entries of maize with their pedigree

Entry No.	Pedigree	Origin	Entry No.	Pedigree	Origin
1.	TQPM 46-1-1-1-⊗-1	1401	43.	TQPM 40-1-1-1-⊗-1	1443
2.	TQPM 31-1-2-1-⊗-1	1402	44.	TQPM 40-1-1-1-⊗-2	1444
3.	TQPM 31-1-1-1-⊗-1	1403	45.	HOL 45-1-2-1-⊗-1	1445
4.	TQPM 34-1-2-1-⊗-1	1404	46.	HOL 45-1-2-1-⊗-2	1446
5.	TQPM 34-1-1-1-⊗-2	1405	47.	HOL 45-1-2-1-⊗-3	1447
6.	TQPM 42-1-2-1-⊗-1	1406	48.	TQPM 46-1-2-#-1-⊗-1	1448
7.	TQPM 42-1-2-1-⊗-2	1407	49.	TQPM 46-1-2-#-1-⊗-2	1449
8.	HOL 9-1-1-1-⊗-1	1408	50.	TQPM 75-1-3-#-1-⊗-1	1450
9.	HOL 9-1-1-1-⊗-2	1409	51.	TQPM 75-1-3-#-1-⊗-2	1451
10.	HOL 9-1-1-1-⊗-1	1410	52.	TQPM 40-3-1-1-⊗-1	1452
11.	HOL 9-1-1-1-⊗-2	1411	53.	TQPM 40-3-1-1-⊗-2	1453
12.	TQPM 37-1-1-1-⊗-1	1412	54.	POP 26-1-1-1-⊗-2	1454
13.	TQPM 37-1-1-1-⊗-2	1413	55.	POP 26-1-1-1-⊗-2	1455
14.	HOL 34-1-1-1-⊗-1	1414	56.	POP 26-1-1-1-⊗-3	1456
15.	HOL 34-1-1-1-⊗-2	1415	57.	TQPM 40-3-1-1-⊗-1	1457
16.	POP 22-1-1-1-⊗-1	1416	58.	TQPM 40-3-1-1-⊗-2	1458
17.	POP 22-1-1-1-⊗-2	1417	59.	TQPM 40-3-1-1-⊗-3	1459
18.	TQPM 38-1-2-1-⊗-1	1418	60.	TQPM 30-2-1-1-⊗-1	1460
19.	TQPM 38-1-2-1-⊗-2	1419	61.	TQPM 30-2-1-1-⊗-2	1461
20.	TQPM 48-1-1-1-⊗-1	1420	62.	TQPM 30-2-1-1-⊗-3	1462
21.	TQPM 48-1-1-1-⊗-2	1421	63.	TQPM 46-1-1-2-⊗-1	1463
22.	TQPM 48-1-1-1-⊗-3	1422	64.	TQPM 46-1-1-2-⊗-2	1464
23.	TQPM 23-1-1-1-⊗-1	1423	65.	TQPM 27-1-1-1-⊗-1	1465
24.	TQPM 23-1-1-1-⊗-1	1424	66.	TQPM 27-1-1-1-⊗-2	1466
25.	TQPM 48-1-1-2-⊗-1	1425	67.	TQPM 27-1-1-1-⊗-3	1467
26.	TQPM 48-1-1-2-⊗-2	1426	68.	TQPM 27-1-1-1-⊗-4	1468
27.	TQPM 48-1-1-1-⊗-1	1427	69.	TQPM 49-3-1-1-⊗-1	1469
28.	TQPM 48-1-1-1-⊗-2	1428	70.	TQPM 49-3-1-1-⊗-2	1470
29.	TQPM 35-2-2-1-⊗-1	1429	71.	TQPM 49-3-1-1-⊗-3	1471
30.	TQPM 35-2-2-1-⊗-1	1430	72.	TQPM 46-2-1-1-⊗-1	1472
31.	TQPM 37-2-1-1-⊗-1	1431	73.	TQPM 46-2-1-1-⊗-2	1473
32.	TQPM 37-2-1-1-⊗-2	1432	74.	TQPM 18-2-1-1-⊗-1	1474
33.	TQPM 37-2-1-1-⊗-3	1433	75.	TQPM 18-2-1-1-⊗-2	1475
34.	HOL 40-1-1-2-⊗-1	1434	76.	AML 12-1-2-1-⊗-1	1476
35.	TQPM 28-1-1-1-⊗-1	1435	77.	AML 12-1-2-1-⊗-2	1477
36.	TQPM 28-1-1-1-⊗-2	1436	78.	TQPM 35-2-1-1-⊗-1	1478
37.	TQPM 31-1-1-1-⊗-1	1437	79.	TQPM 35-2-1-1-⊗-2	1479
38.	TQPM 31-1-1-1-⊗-2	1438	80.	TQPM 44-2-1-1-⊗-1	1480
39.	TQPM 48-1-1-2-⊗-1	1439	81.	TQPM 44-2-1-1-⊗-2	1481
40.	TQPM 48-1-1-2-⊗-2	1440	82.	HOL 68-2-1-1-⊗-1	1482
41.	M210 1-1-2-⊗-2	1441	83.	HOL 68-2-1-1-⊗-2	1483
42.	M210 1-1-2-⊗-2	1442	84.	AML 119-1-1-1-⊗-1	1484

Entry No.	Pedigree	Origin	Entry No.	Pedigree	Origin
85.	AML 119-1-1-1-⊗-2	1485	127.	TQPM 37-1-1-1-⊗	1536
86.	TQPM 27-1-1-1-⊗-1	1486	128.	TQPM 28-1-1-4-⊗	1537
87.	TQPM 27-1-1-1-⊗-2	1487	129.	POP 22-1-1-1-⊗	1538
88.	HOL 65-3-1-1-⊗-1	1488	130.	TQPM 38-1-2-1-⊗	1539
89.	HOL 65-3-1-1-⊗-2	1489	131.	TQPM 47-1-1-1-⊗	1540
90.	HOL 65-3-1-1-⊗-3	1490	132.	TQPM 48-1-1-1-⊗	1541
91.	TQPM 27-1-1-1-⊗-1	1491	133.	TQPM 26-1-1-1-⊗	1542
92.	TQPM 27-1-1-1-⊗-2	1492	134.	HOL 74-1-2-1-⊗	1543
93.	HOL 31-1-1-1-⊗-1	1493	135.	HOL 48-2-1-1-⊗	1544
94.	HOL 31-1-1-1-⊗-2	1494	136.	HOL 39-2-1-1-⊗	1545
95.	HOL 65-5-1-2-⊗-1	1495	137.	TQPM 80-1-2-1-⊗	1546
96.	HOL 65-5-1-2-⊗-2	1496	138.	HOL 58-1-1-1-⊗	1547
97.	AML 18-4-1-2-⊗-1	1497	139.	HOL 45-1-2-1-⊗	1548
98.	AML 18-4-1-2-⊗-2	1498	140.	TQPM 75-1-3-#-⊗	1549
99.	TQPM 83-4-1-1-1-⊗-1	1499	141.	POP 27-2-1-1-⊗	1550
100.	TQPM 83-4-1-1-1-⊗-2	1500	142.	POP 85-3-1-1-⊗	1551
101.	HOL 66-1-1-3-#-1	1501	143.	POP 45-3-1-1-⊗	1552
102.	HOL 66-1-1-3-#-2	1502	144.	TQPM 30-2-1-1-⊗	1553
103.	TQPM 33-4-1-1-⊗-1	1503	145.	AML 1K-1-1-1-⊗	1554
104.	TQPM 33-4-1-1-⊗-2	1504	146.	HOL 68-2-1-1-1-⊗	1555
105.	TQPM 43-3-1-1-⊗-1	1505	147.	TQPM 44-2-1-1-⊗	1556
106.	TQPM 43-3-1-1-⊗-2	1506	148.	HOL 66-1-1-2-⊗	1557
107.	TQPM 43-3-1-1-⊗-3	1507	149.	AML 18-4-1-1-⊗	1558
108.	M210 2-1-1-⊗-1	1508	150.	DMR QPM -56	1601
109.	M210-2-1-1-⊗-2	1509	151.	DMR QPM -57	1602
110.	TQPM 44-2-1-1-⊗-1	1510	152.	DMR QPM -58	1603
111.	TQPM 44-2-1-1-⊗-2	1511	153.	DMR QPM -65	1604
112.	TQPM 44-2-1-1-⊗-3	1512	154.	DMR QPM -66	1605
113.	TQPM 35-2-1-1-⊗-1	1513	155.	DMR QPM -68	1606
114.	TQPM 35-2-1-1-⊗-2	1514	156.	DMR QPM -71	1607
115.	TQPM 27-1-1-1-#-1-1	1515	157.	DMR QPM -72	1608
116.	TQPM 27-1-1-1-#-1-2	1516	158.	DMR QPM -73	1609
117.	TQPM 12-1-2-1-⊗-1	1517	159.	DMR QPM -74	1610
118.	TQPM 12-1-2-1-⊗-2	1518	160.	DMR QPM-3	1611
119.	TQPM 12-1-2-1-⊗-3	1519	161.	DMR QPM -4	1612
120.	TQPM 36-2-1-1-⊗-1	1520	162.	DMR QPM -7	1613
121.	TQPM 36-2-1-1-⊗-2	1521	163.	DMR QPM -9	1614
122.	TQPM 31-1-2-1-⊗-	1522	164.	DMR QPM -10	1615
123.	TQPM 42-1-2-1-⊗-	1523	165.	DMR QPM -11	1616
124.	HOL 9-1-1-1-⊗	1524	166.	DMR QPM -12	1617
125.	HOL 45-2-1-1-⊗	1525	167.	DMR QPM -13	1618
126.	73-1-2-1-⊗	1526	168.	DMR QPM -14	1619
			169.	DMR QPM -15	1620

estimated by Kjeldahl's method with a factor of 6.25. The data were analyzed as per standard procedure (Panse and Sukhatme, 1961) for the estimation of variances, co-efficient of variances, heritability in broadsense (h^2) and genetic advance as per cent of mean [Burton (1952), Johnson *et al.* (1955)].

Results and Discussion

The information on genetic variability for different characters of economic importance is pre-requisite for a plant breeder to work with any crop improvement programme (Vavilov, 1951). In the present investigation we have used 169 genotypes for agronomic and quality significant differences between the test entries were observed for all the agronomic and quality parameters (Table 2). Among the traits studied, highest variability was observed for grain yield followed by ear length, protein yield, 100-seed weight and number of seeds per row while lowest variability was recorded for days to 50% silking (Table 3). In general, the study revealed sufficient variability for all the agronomic and quality parameters and thus helped in selection of specific parents for different characters. These observations were in accordance with the findings of Pamin (1986), Chandramohan (1999) and Venugopal (2000).

The characters viz., grain yield per plot, protein yield, number of seeds per row, ear length and 100-seed weight exhibited higher values of genotypic and phenotypic co-efficient of variations. The narrow difference between PCV values for these characters indicate that, the traits are more influenced by genetic factors with minimum influence of environment and also suggest that, the selection based on these characters would facilitate, successful isolation of desirable genotypes. Singh *et al.* (1995), Mani and Bisht (1999) and Venugopal (2000) were earlier reported similar type of observations for grain yield, protein content and other plant characters.

The GCV alone is not sufficient for the determination of amount of heritable variation. Burton (1952) suggested that, GCV together with the heritability estimates would give the best picture of the extent of advance to be expected by selection. In the present study, most of the characters exhibited high heritability values but the highest heritability was observed for days to 50% maturity followed by grain yield per plot, plant height, protein content, protein yield and number of seeds per row, while moderate to high

Table 2. Analysis of variance for 14 characters in maize

S.No.	Characters	M.S.S.		C.V. (%)
1.	Days to 50% tasselling	36.698**	2.9855	2.4293
2.	Days to 50% silking	37.437**	1.7220	1.2702
3.	Days to 50% maturity	42.348**	2.2755	1.0298
4.	Plant height (cm)	1443.312**	6.0199	1.8297
5.	Ear height (cm)	234.743**	5.5712	5.0283
6.	Ear length (cm)	13.873**	0.7679	4.0283
7.	Ear girth (cm)	5.108**	0.7171	3.6556
8.	No. of seed rows per cob	6.474**	1.4326	5.2340
9.	No. of seeds per row	75.221**	1.5625	3.5240
10.	1 OO-Seed weight (g)	50.456**	1.5911	3.8207
11.	Protein content (%)	3.558**	0.3328	1.4806
12.	Protein yield (kg/ha)	4347.738**	37.4150	4.0842
13.	Oil content (%)	1.0931**	0.3404	3.5241
14.	Grain yield per plot (kg)	0.795**	0.1343	4.1510

**Significant at 1% level of significance.

Table 3. Estimates of genetic variability for 14 characters in maize

S.No.	Characters	Mean	Range		GCV (%)	PCV (%)	Heritability (%)	Genetic advance	Genetic adv. as per cent of mean (%)
				Maximum					
1.	Days to 50% tasselling	60.25	50.00	70.50	6.37	6.83	86.9	7.60	12.61
2.	Days to 50% silking	68.00	57.00	79.00	6.24	6.38	95.5	8.61	12.66
3.	Days to 50% maturity	109.50	78.50	120.50	4.05	4.18	98.9	9.04	8.25
4.	Plant height (cm)	162.73	106.85	218.60	16.09	16.19	98.7	54.80	33.67
5.	Ear height (cm)	52.07	27.20	76.95	29.00	19.65	93.4	21.20	4071
6.	Ear length (cm)	10.80	2.78	18.82	27.15	27.46	97.8	5.33	49.35
7.	Ear girth (cm)	9.76	5.28	14.25	15.89	16.31	94.9	3.17	32.47
8.	No. of seed rows per cob	13.91	8.91	18.90	12.44	13.49	85.0	3.27	23.51
9.	No. of seeds per row	26.75	10.00	43.50	27.19	27.42	98.3	12.48	46.65
10.	100-Seed weight (g)	22.51	8.18	36.85	23.67	24.01	97.1	10.12	44.95
11.	Protein content (%)	10.68	7.88	13.50	11.68	11.78	98.4	2.72	25.46
12.	Protein yield (kg/ha)	497.18	147.42	846.96	32.44	32.71	98.4	299.84	60.30
13.	Oil content (%)	5.42	3.07	6.16	10.94	11.50	10.60	1.16	39.74
14.	Grain yield per plot (kg)	1.80	0.45	3.15	38.89	38.61	98.8	1.29	71.66

**Significant at 1% level of significance.

Table 4. Superior maize genotypes identified as parents having high protein coupled with high oil and grain yield

S.No.	Entry No.	Pedigree	Grain yield per plot (kg)		Protein content (%)	Protein yield (kg/ha)	Oil content (%)
1.	15	HOL 34-1-1-1-⊗-2	2.03	2713.33	12.07	663.21	6.16
2.	42	$M_2$10-1-1-2-⊗-2	2.51	3393.31	11.02	756.07	5.65
3.	53	TQPM -40-3-1-1-⊗-2	2.46	3359.98	11.02	739.53	5.20
4.	60	TQPM -30-2-1-1-⊗-1	2.65	4066.64	10.78	782.27	5.05
5.	67	TQPM -27-1-1-1-⊗-3	2.19	2939.98	11.65	662.84	4.04
6.	69	TQPM-49-3-1-1-⊗-1	2.63	3513.31	11.30	806.79	5.81
7.	87	TQPM-27-1-1-1-⊗-2	2.04	2839.98	10.59	590.97	5.52
8.	104	TQPM-33-4-1-1-⊗-2	2.60	3433.31	10.73	762.41	7.70
9.	117	TQPM-12-1-2-1-⊗-2	2.84	3873.31	10.29	801.57	5.72
10.	138	TQPM-58-1-1-1-⊗	2.37	3119.84	10.32	670.89	5.09

heritability estimates were observed only for days to 50% tasselling and number of seed rows per ear. The characters ear length. number of seeds per row. 100-seed weight, protein yield, oil content and grain yield per plot showed high GCV estimates along with high heritability there by pointing to the improvement of these characters through simple per se selection and using them in future hybrid breeding programme for the development of heterotic hybrids. These results were in agreement with the observations of Debnath (1987). Satyanarayana and Sai Kumar (1996). Tusuz and Balabanli (1997) and Mani and Bisht (1999).

The heritability estimates indicate only the effectiveness with which selection of genotype can be based on the phenotypic performance but fail to indicate the real progress. Therefore, high heritability need not always accomplished by genetic progress. However, high herability estimates along with high genetic gain render the selection more effective (Johnson *et al.*, 1955). In this study, the genetic advance, as percent of mean along with high heritability estimates was maximum for grain yield per plot, followed by protein yield. This indicates that the genetic variances for these two traits are probably owing to their high additive gene effects (Johnson *et al.*, 1955) and thus there is better scope for improvement of these traits through direct selection. While the traits, ear length, number of seeds per row, 100-seed weight, ear height, oil content, plant height, ear girth and protein content showed moderate genetic advance as percent of mean along with high heritability values indicating that, the improvement of these characters is possible only through careful directional and restricted selection. The other characters viz., days to 50% tasselling, days to 50% silking and number of seed rows per cob recorded low genetic advance coupled with moderate to high heritability estimates and the character days to 50% maturity had recorded low genetic advance coupled with high heritability estimates revealing the predominance of non-additive gene action and hence improvement of such traits is complicated and it might be possible through heterosis breeding. Thus the present results confirm the earlier findings of Debnath (1987), Tusuz and Balabanli (1997) and Mani and Bisht (1999).

In brief, it can be concluded that, the traits namely grain yield per plot and protein yield are the most important parameters to be considered for effective selection of parental lines to develop high yielding quality protein maize (QPM) hybrids, as these two characters exhibited high variability, heritability combined with high genetic advance as per cent of mean. Among 169 QPM and high oil maize genotypes, ten best lines were identified for their good agronomic and quality parameters (Table 4) and suggested for their use in future breeding programme in developing high yielding potential QPM hybrids.

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DIRECT AND RESIDUAL EFFECT OF HERBICIDES, PHOSPHATE SOLUBILIZERS USED IN WHEAT ON THE PRODUCTIVITY AND PROFITABILITY OF WHEAT (*TRITICUM AESTIVUM* L.)—FODDER MAIZE (*ZEA MAYS*) SYSTEM

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Abstract

A field experiment was conducted at Instructional Farm, Rajsthan College of Agriculture, Udaipur. The results indicated that pendimethalin being at par with other herbicides, produced the highest grain (47.2 q/ha) and biological (110.5 q/ha) yields closely followed by isoproturon. However, maximum net return (Rs 33073 /ha) and B:C ratio (3.60) were obtained from isoproturon. Phosphorus fertilization at 45 kg P_2O_5/ha significantly enhanced the yield as well as net return (Rs. 31467/ha) and B:C ratio (3.20) over 30 kg P_2O_5/ha. Seed inoculation with PSB had significant positive effect on wheat yields, net return (Rs. 31336/ha) and B: C ratio (3.18) as compared to no inoculation. Fodder yield and economics of maize was not influenced significantly due to herbicides applied in preceding wheat crop. Application of 60 kg P_2O_5/ha to preceding wheat crop had significant residual effect and produced higher green fodder yield (5.9%), net return (Rs. 19526/ha) and B: C ratio as compared to 30 kg P_2O_5/ha. Further, system productivity as wheat equivalent yield, net return and B: C ratio was also influenced significantly due to use of herbicides, phosphorus and PSB in wheat.

Key words : Herbicides, phosphorus, phosphate solubilizer, productivity, profitability, residual effect.

During the post green revolution period, the productivity of wheat has increased tremendously but it is still far below the potential (11.2 t/ha) levels. Of the several constraints to productivity of wheat, weeds have bee recognized as an important one, which competes with crop plants for water, nutrients, space and solar radiations resulting in reduction of yields by 20 to 50% (Bhan, 1998). To achieve higher productivity levels, our nutrient management strategies are also equally important and the recommendations should be situation specific to have maximum quality produce. Phosphorus, a key nutrient should be optimized for improving quality and quantity of the produce. But, the prices of phosphatic fertilizers are increasing day-by-day. Under such situations, suitable alternatives are to be evaluated. Phosphate solubilising bacteria (PSB) may be one of the best alternative for improving fertilizer use efficiency.

After introduction of short statured cereal hybrids having higher harvest index, the need for cultivation of fodder crops on arable land is keenly felt. During last decade, maximum arable land of the country has been put under grain and cash crops due to which the farmers are often facing acute fodder shortage. Maize in an ideal crop possessing quick growing habit, high yielding ability, palatability and nutritious ness and can be fed at any stage of growth, as there is no problem of hydrocyanic acid or oxalic acid poisoning to cattle. Both wheat and maize crops are heavy feeder of nutrients especially phosphorus. The fertilizer recommendations for phosphorus application based on crop sequences may be much more beneficial in view of soil susceptibility and economics. An effort on these aspects as an integrated approach has not been made so far under Central Plateau and Hills Zone of India, therefore, this investigation was carried out.

Materials and Methods

A field experiment was conducted during consecutive *rabi* and *summer* seasons of the 1998-

99 and 1999-2000 on Instructional Farm, Rajasthan College of Agriculture, Udaipur. The soil of experimental site was clay loam in texture, slightly alkaline in reaction (pH 8.0) and calcareous in nature. The soil was medium in available nitrogen (270 kg/ha), phosphorus (17 kg/ha) and rich in potassium (379 kg/ha) status. The experiment was laid out in a split-plot design with four replications. The treatment combinations consisted of five herbicidal weed management (weedy check, isoproturon@ 0.75 kg/ha, fluroxypyr@ 200 g/ha, tralkoxydim@ 400 g/ha, pendimethalin @ 1.0 kg/ha) in main plots, three levels of phosphorous (30, 45 and 60 kg P_2O_5/ha) and two levels of PSB inoculation (uninoculated and inoculated) in sub-plots.

The wheat cv. Raj-3077 was used for experimental purpose. The seeds were inoculated just before sowing with phosphate solubilizing bacteria (*Bacillus megatherium*) @ 5 g/kg seed as per treatment. The sowing was done on 26th and 25th November in 1998 and 1999, respectively using 100 kg seed/ha. The wheat crop was supplied with recommended dose of nitrogen (120 kg N/ha) and phosphorus as per treatment. Half dose of nitrogen (60 kg/ha) was applied through DAP and urea as basal, phosphorus through DAP and inoculation of seeds with PSB culture at the time of sowing and remaining half of N was top dressed in two equal splits, first at crown root initiation and second at full tillering. The herbicide pendimethalin was sprayed as pre-emergence, two days after sowing and remaining three post-emergence herbicides i.e. isoproturon, fluroxypyr and tralkoxydim were applied at 30 DAS as per treatments. The crop was irrigated at all the six critical growth stages during both the years. After harvest of wheat, each experimental plot was prepared without disturbing original plan of layout. Maize variety Ganga-5 was sown at a spacing of 30 cm using 45 kg seed per hectare on 18th and 20th April in respective years. Nitrogen was applied through urea @ 90 kg/ha in two equal splits at sowing and at first irrigation. Harvesting of maize was done between 60-65 days after sowing of the crop.

RESULTS AND DISCUSSION

Wheat productivity and profitability

The results of the experiment showed that application of herbicides resulted in significant improvement in yields and economics of wheat, compared to weedy check (Table 1). The yield improvement due to weed management through different herbicides varied according to their efficacy but was found statistically on par with each other. Further, pendimethalin being a broad-spectrum herbicide, resulted in maximum increment in grain (47.2 q/ha), straw (63.3 q/ha) and biological (110 q/ha) yields of wheat followed by isoproturon. Tralkoxydim being superior to weedy check had lowest yield increment compared to all other herbicides. The least response of tralkoxydim was due to higher density of broad leaf weeds in the experimental field and its narrow spectrum nature, which kills mainly grassy weeds. Pendimethalin and isoproturon had highest yield increment mainly due to better control of grassy as well as broad leaf weeds, which reduced the comparativeness of the crop and ultimately resulted in improved yield of the crop. The net return (Rs. 33073/ha), returns per rupee investment (3.60) indicated that isoproturon was most profitable as compared to rest of the treatments followed by pendimethalin (Rs. 32563/ha and 3.16, respectively). Similar results have also been reported by Walia *et al.* (1998).

Phosphorus fertilization at 45 kg/ha had brought marked improvement in yield of wheat compared to 30 kg/ha, but remained at par with 60 kg P_2O_5/ha during both the years of study (Table 1). However, maximum grain (47.0 q/ha), straw (61.6 q/ha) and biological (108.6 q/ha) yields were recorded with 60 kg P_2O_5/ha but failed to produce significant improvement at higher level. This improvement in yield might have been mainly due to adequate supply of phosphorus, which helped in maintaining, better source-sink inter-relationship by increasing sink capacity by its key role in energy transformation. Further, increased phosphorous supply influenced root mass development, which

Table 1. Effect of herbicides, phoshorus and PSB on productivity and profitability of wheat-maize (F) cropping system

	Wheat yield (q/ha)			Maize fodder yield (q/ha)		Wheat grain equivalent yield (q/ha)	Net return (Rs./ha)			B: C ratio		
	Grain	Straw	Biological	Green	Dry		Wheat	Maize (F)	System	Wheat	Maize (F)	System
Herbicides												
Weedy check	38.2	43.5	81.7	344.7	82.8	70.3	25154	18434	43588	2.87	3.23	4.02
Isoproturon	46.6	62.2	108.7	354.6	85.5	79.7	33073	19124	52197	3.60	3.37	4.50
Fluroxyr	45.7	60.3	106.0	350.9	84.4	78.4	30651	18860	49511	2.86	3.31	4.02
Tralkoxydim	44.9	59.5	104.5	345.6	83.1	77.2	30322	18490	48812	2.91	3.24	4.03
Pendimethalin	47.2	63.3	110.5	356.4	85.9	80.5	32563	19245	51725	3.16	3.37	4.24
CD (P=0.05)	2.65	4.16	7.07	NS	NS	6.53	1922	NS	3303	0.19	NS	0.37
Phosphorus (kg P_2O_5/ha)												
30	40.8	52.7	93.3	340.2	82.2	71.9	26721	18116	44695	2.78	3.15	3.91
45	45.8	59.1	104.8	350.7	84.4	78.5	31467	18850	50267	3.20	3.31	4.24
60	47.0	61.6	108.6	360.3	86.5	80.6	32440	19526	51966	3.22	3.42	4.29
CD (P=0.05)	1.40	2.70	4.53	12.04	2.76	4.37	1039	839	1935	0.12	0.14	0.24
PSB Inoculation												
Uninoculated	43.4	56.5	99.9	348.4	84.1	75.8	29369	18649	48019	2.98	3.27	4.09
Inoculated	45.6	59.0	104.7	352.4	84.7	78.6	31336	19012	50315	3.18	3.34	4.23
CD (P=0.05)	1.14	2.20	3.69	NS	NS	2.71	848	NS	1580	0.08	NS	0.13

performs indirect function for formation of hormones cytokinins, which promotes flower initiation in several plants. Sahu *et al.* (1999) also reported significantly higher grain yield of wheat with the application of 45 kg P_2O_5/ha.

Inoculation of seeds with PSB resulted in significant improvement in the yield and economics of wheat compared to no inoculation (Table 1). A significant improvement in grain (5.1%), straw (4.4%) and biological (4.8%) yield of wheat, returns (Rs. 2296/ha) and B:C ratio (3.18) were recorded with inoculation of seeds with PSB over no inoculation. Results of several trials have also showed that seed inoculation with PSB increased the yield of wheat, rice, black gram, potato and soybean (Singh and Kapoor, 1999).

Maize (F) productivity and profitability

Herbicidal weed management practices adopted in preceding wheat crop had slight influence on fodder yield and economics of succeeding fodder maize (Table 1). The residual effect of 60 kg P_2O_5/ha applied to preceding wheat crop significantly improved the green fodder (360 q/ha), dry fodder (86.5 q/ha), net return (Rs. 19526/ha) and B:C ratio (3.42) in succeeding fodder maize as compared to 30 kg P_2O_5/ha. The increase was to the tune of 5.9, 5.2, 7.8 and 9.7 per cent, respectively over 30 kg P_2O_5/ha. However, 45 kg P_2O_5/ha remained at par with aforesaid levels of these parameters might be mainly due to increased availability of phosphorous through addition of 60 kg P_2O_5/ha which ultimately improved the fodder yield and economics by the crop. The findings confirm the results of Negi *et al.* (1992) and Ramamurthy and Shivashankar (1996). Seed inoculation of wheat with PSB had no significant influence on, fodder yield and economics of succeeding maize.

Wheat-maize (F) system productivity and profitability

The productivity of wheat-maize (fodder) system was also significantly influenced due to different treatments applied to the wheat crop (Table 1). Higher system productivity (9.8 to 14.5%) as wheat grain equivalent yield (WEY), net return (Rs. 5224 to 8609/ha) and B: C ratio (4.02 to 4.50) were recorded due to application of herbicides in wheat as compared to weedy check (70.3 q/ha, Rs 43588/ha and 4.02, respectively). Further, isoproturon @ 0.75 ka/ha proved most economical with net return Rs. 52197/ha and B: C rario 4.50 closely followed by pendimethalin @ 1.0 kg/ha (Rs. 51725/ha and 4.24, respectively). However, maximum wheat grain equivalent yield (80.5 q/ha) was produced with pendimethalin followed by isoproturon (79.7 q/ha).

Phosphorus fertilizer to wheat crop also showed significant influence on productivity and profitability of the wheat-maize (F) system (Table 1). Application of 45 kg P_2O_5/ha being on par with 60 kg P_2O_5/ha, gave significantly higher wheat grain equivalent yield (78.5 q/ha), system net return (Rs. 50267/ha) and B: C ratio (4.24) than 30 kg/ha. However, maximum WEY (80.69 q/ha), system net return (Rs. 51966/ha) and B: C ratio (4.29) were recorded with the use of 60 kg P_2O_5/ha to the wheat crop. Further, system productivity and profitability was also significantly affected due to seed inoculation of wheat with PSB (Table 1). Seed inoculation of wheat produced significantly higher WEY (3.7%), system net return (Rs. 2296/ha) B: C ratio (3.4%) over no inoculation (75.8 q/ha, Rs. 48019/ha and 4.09, respectively).

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PERFORMANCE OF TOMATO (*LYCOPERSICON ESCULENTUM* L.) AS INFLUENCED BY TRANSPLANTING TIMES AND CULTIVATION METHODS IN FOOTHILLS OF NAGALAND

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ABSTRACT

Performance of tomato to different dates of transplanting *viz.*, 2nd and 3rd week of August, 2nd and 3rd week of September and 2nd week of October with 4 cultivation methods *viz.*, plain bed, plain bed with staking, raised bed and raised bed with staking were studied on sandy loam soil during 2002-2003. Results showed that transplanting in second week of August recorded the highest yield (317.49 q/ha), followed by 3rd week of August (304.67 q/ha) which was significantly superior as compared to 2nd and 3rd week of September transplanting (290.32 and 282.16 q/ha, respectively). Late transplanting significantly reduced fruit weight, number of fruits whereas crop stand showed improvements. In both plain and raised bed with staking significantly reduced the unmarketable yield. Cultivation methods had no influence on crop stand and number of locule/fruit. Raised bed with staking method maximum plant height (93.69 cm), fruit (46.32) and yield (286.17 q/ha) which were significantly superior as compared to plain bed.

Tomato is one of the most important and popular solanceous vegetables grown in India due to its special nutritive value, high productivity, great processing potentiality and wide ecological amplitude (Singh *et al.*, 2000 and Babu *et al.*, 2001). Cultivation of tomato in monsoon season is assuming great importance in the north - eastern region in general and in Nagaland in particular owing to its high prices of produce obtained from other parts of the country during this period. Popularization of tomato cultivation among the local farmers requires standardization of agro-techniques. Though the agro-climatic condition of Nagaland is quite favourable and there is tremendous scope for taking up commercial cultivation of this vegetable, the standardization of horticultural practices has not been done so far under local agro-climatic condition for its profitable cultivation. Therefore, the present study was conductd to get the information regarding planting time and cultivation system of tomato for obtaining higher yield under foot-hill condition of Nagaland.

MATERIAL AND METHODS

Field experiment was carried out at ICAR Research Complex for NEH Region Nagaland Centre, Jharnapani during 2002-2003 on a standy loam soil, having pH 5.6, organic carbon 0.79% and available NPK 56.40, 37.76 and 147.08 kg/ha, respectively. The experiment was laid out in a randomized block design with three replications, in a plot measuring 9.0 sq. mt (3.0 x 3.0 mt) with a spacing of 60 cm x 60 cm. Treatments consisted of 5 transplanting times i.e. 2nd and 3rd week of August, 2nd and 3rd week of September and 2nd week of October with 4 cultivation systems *viz.* plain bed, plain bed with staking, raised bed and raised bed with staking. A uniform dose of well decomposed framyard manures @ 30 t/ha was applied 15 days before transplanting. A fertilizer dose of NPK @ 80:60:60 kg/ha was also applied. Half dose of nitrogen (as urea) and full dose of phosphorus (as single super phosphate) and potassium (as muriate of potash) were applied a day before transplanting and remaining half dose of nitrogen was supplied as a top dressing in two splits. Other recommended cultural practices were followed.

Observations on plant height, fruit/plant, crop stand, weight of fruit, number of locules/fruit, yield, unmarketable and marketable yield were recorded and statistically analyzed.

RESULTS AND DISCUSSION

The vegetative growth and fruit yield of tomato were significantly influenced by transplanting time (Table 1). Plant height was maximum (87.69 cm) under 3rd week of August planting followed by 2nd week of August planting (81.45 cm). Lowest plant height was recorded by 2nd week of October transplanting (66.72 cm). Significantly more fruits were observed in 3rd week of August transplanting (46.21), followed by 2nd week of August transplanting (41.36). Lowest fruit/plant (32.75) were recorded in 3rd week of September transplanting. Tansplanting of tomato in 2nd week of August gave significantly higher fruit weight (63.12 g) as compared to September and October plantings. Transplanting done in the middle of September recorded significantly higher stand of crop (81.36%) at final harvest compared to 2nd and 3rd week of August (49.35 and 70.17%, respectively) and 2nd week of October plantings. This may be due to favourable weather conditions prevailing in second week of September for transplanting of tomato. Number of locules/fruit was not significantly affected by time of planting. Observation revealed that maximum yield were recorded with 2nd week of August transplanting (317.49 h/ha) followed by 3rd week of August transplanting (304.67 q/ha) which was significantly higher as compared to 2nd and 3rd week of September transplanting which were at par with each other. Delaying transplanting of tomato resulted in significantly reduced yield (256.47 q/ha). This was due to heavy rains which adversely affected the growth, flowering and fruiting (Rao, 1986). A positive effect of delayed transplanting was observed in unmarketable yield. The lowest unmarketable yield was obtained in 2nd week of October (17.41%) as compared to 2nd and 3rd week of August (29.63 and 26.18%, respectively) and 2nd week of September (23.63%) transplanting. Delaying of transplanting upto 2nd week of September reduced number of marketable fruits (23.49/m^2) but a significant effect was recorded only in case

Table 1. Effect of different time of transplanting and system of cultivation on growth and yield of tomato

Treatment	Plant height (cm)	No. of fruits /plant	Crop stand (at final harvest)	Weight of fruit (g)	No. of locules/ fruit	Yield (q/ha)	Unmarketable yield (%)	Marketable yield (fruits/m^2)
Time of transplanting								
2nd week of August	81.45	41.36	49.35	63.12	3.09	317.49	29.63	31.60
3rd week of August	87.69	46.21	70.17	55.45	3.01	304.67	26.18	27.37
3rd week of September	77.19	37.40	81.36	53.14	2.87	290.32	23.63	23.49
3rd week of September	70.38	32.75	71.25	45.67	2.76	282.16	19.07	17.10
2nd week of October	66.72	34.67	65.51	51.69	2.83	256.47	17.41	26.57
CD (P=0.05)	9.43	4.10	10.70	7.29	NS	10.14	6.13	8.16
System of cultivation								
Plain bed	70.15	34.72	63.24	56.25	2.67	237.12	33.89	22.01
Plain bed with staking	82.36	40.13	69.54	68.31	2.95	279.63	21.40	28.49
Raised bed	76.30	37.51	66.40	61.38	2.80	267.36	28.34	24.84
Raised bed with staking	93.69	46.32	72.12	66.02	2.87	286.17	18.17	30.12
CD (P=0.05)	11.28	7.24	NS	NS	NS	12.34	6.30	5.15

of 3rd week of September planting (17.10 fruit/m^2). Further delay in planting increased in the number of marketable fruits but difference was not significant.

The plant height was significantly affected by cultivation systems. Highest plant height (93.69 cm) was recorded by raised bed with staking and was significantly higher than other cultivation system. Lowest plant height (70.15 cm) was observed under plain bed. Maximum fruits/plant were recorded by raised bed with staking (46.32) which were significantly higher as compared to plain bed and raised bed (34.72 and 37.51, respectively) systems but at par with plain bed with staking (40.13). Cultivation system did not significantly affect the crop stand. Maximum crop stand (72.12%) at final harvest was recorded in raised bed with staking and minimum crop stand was found in plain bed (63.24%). Further cultivation systems had no significant effect on fruit weight and number of locules/fruit. The highest fruit weight was recorded in plain bed with staking (68.31 g) followed by raised bed with staking (66.02 g). However, lowest fruit weight was obtained under plain bed (56.25 g). A similar trend was also observed in case of locules. System of cultivation significantly influenced total yield. Maximum yield (286.17 q/ha) was recorded by raised bed with staking and it was significantly superior as compared to other cultivation systems. Minimum yield (237.12 q/ha) was however, recorded under plain bed (Table 1). The results are in agreement with the findings of Olasantan (1985), Kimoto *et al.* (1984), Narayana and Rama Rao (1981) and Singh (1994) in tomato. The highest fruit yield in staking system might be due to the availability of more spacing, receiving more sun light and aeration for the promotion of photosynthesis and plant metabolism for assimilation of nutrients and food reserve for higher yield. Staking of plants significantly reduced the unmarketable yield in both plain bed (21.40%) and raised bed (18.17) as compared to plain bed and raised bed which were at par with each other. Staking either in plain bed or in raised bed system recorded significantly higher marketable fruit. Highest marketable fruit/m^2 (30.12) was recorded in raised bed with staking followed by plain bed with staking (28.49) which were at par with each other but significantly superior than other cultivation systems. Lowest marketable fruit/m^2 (20.01), were obtained in plain bed.

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VALIDATION AND POPULARIZATION OF IPM TECHNOLOGY IN COTTON THROUGH FARMERS PARTICIPATORY APPROACH IN TRIBAL AREA OF SOUTHERN RAJASTHAN

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ABSTRACT

The IPM Technology was validated and popularized in village Badgaon, Banswara, Rajasthan through farmers field experiments and farmers fields schools during *kharif* 2003 and 2004. The IPM module *viz.*, summer ploughing and clean cultivation, early and synchronous sowing of variety G.H.-8, sowing of border trap crop of maize intervene with cowpea all around the cotton field, sowing of setaria in between every 9th and 10th row of cotton which act as a perch crop for birds, installation of pheromone traps all three species of Bollworms @5 traps/ha keeping the height of traps 1 foot above the crop canopy, spray of methyl demeton 25 EC 0.04% at 30 - 35 days after germination, two spray of Neem seed Kernal extract at 45 and 55 days, spray of HaNPV @ 250 LE/ha at 65 DAG, two releases of *Trichogramma chilonis* @ 1.5 lac/ha at 75 and 85 DAG, need base spray of conventional insecticides was applied in an area of 10 ha field. Farmers field Schools were organized at regular interval to develop the skill and awareness of the farmers about the pests, nature of damage, applicaton of IPM component and natural enemies of the pests. The results of IPM Technology was compared with Non IPM farmers practices which includes 9-10 spray of insecticides. The IPM module reduced the population of sucking insect pests *viz.*, aphids (*Aphis gossypii* Glover), Jassids (*Amrasca bigutulla bigutulla* Ishida), White Fly (*Bemisia tabaci* Genna.), Thrips (*Thrips tabaci* Lindeman) and bollworms *viz.*, *Earias insulana* Fab. and *Helicoverpa armigera* Hub. over non IPM. The mean percent damage to square, flower, green boll, open boll and locule was found less in IPM field as compared to Non IPM fields. The mean seed cotton yield in IPM fields was 1918 and 1804 kg/ha as against 1488 and 1518 kg/ha in non IPM field during 2003 and 2004, respectively. The IPM module also encouraged the population of coccinellids and *Chrysoperla carnea* and spiders.

Key words : IPM technology, validation, farmers field schools, HaNPV, pheromone traps, NSKE, *T. Chilonis.*

In India, cotton is cultivated in the area of 8.15 million ha with an average yield of 306 kg lint/ha. It occupies over 20 percent of total area under cotton in the world but contribute only 12 percent to the global production. The productivity of cotton in the country is lower than in the cotton growing countries of the world *viz.*, China, USA, Russia and Pakistan. The insect pests are one of the most important reason, responsible for the low productivity. The sucking pests and bollworms on an average caused 52.1% loss of seed cotton yield (Dhawan *et al.* 1988). The cotton crop in the Southern Rajasthan is attacked by large number of insect pests right from sowing to the picking. Of which, the aphids (*Aphis gossypii* Glover), Jassids (*Amarsca bigutulla bigutulla* Ishida), White Fly (*Bemesia tabaci* Genna.), Thrips (*Thrips tabaci* Lindeman), Red Cotton bug (*Dysdercus cingulatus* Fab.), dusky cotton bug (*Oxycarenus laetus* Kirby), leaf roller (*Sylepta derogata* Fab.), semi looper (*Tarache notabilis* Walker and *Anomis flava* Fab.), Spotted bollworm (*Earias insulana* Fab.), American bollworm (*Helicoverpa armigera* Hubner) and pink boll worm (*Pectinophora gossypiella* Saund.) and Tobacco caterpillar (*Spodoptera litura* Fab.) are important insect pests which causes considerable losses in cotton.

More than 50 percent of the total pesticides consumption in the country are used on cotton crop which occupies only 5 percent of the total cultivated area. The indiscriminate and excessive use of insecticides resulted in the development

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of resistance to insecticides in insects and the resurgence of insect pests (Dhawan, 1998). To over come all these problems, the Integrated Pest Management is only the remedy. The successful results of IPM has earlier been reported by Vadodaria *et al.* (1988) and Renou *et al.* (2001). The integrated Pest Management Technology as successfully implemented at village level at "Astha" in Maharastra (Singh *et al.* 2002). Earlier, the successful story of IPM validation and popularization through Farmers Field School has been reported by Thulasiram *et al.* (2003) which convince farmers about the eco friendly, safe, economically viable and less hazardous pest management strategy. Keeping all the facts in view, an IPM module was developed, validated and popularized on larger scale at farmer's field and the results were compared with non IPM fields.

MATERIALS AND METHODS

The IPM module was developed, validated and popularized through demonstration and Farmers Field School at farmer's field in 10 ha at Badgaon village of Banswara, Rajasthan during *kharif* 2003 and 2004. The IPM module comprised on the following; summer ploughing and clean cultivation, early and synchronous sowing of variety G.H.-8, sowing of boarder trap crop of maize intervene with cowpea all around the cotton field, sowing of setaria in between every 9th and 10th row of cotton which act as a perch crop for birds, installation of pheromone traps for all three species of Bollworms @ 5 traps/ha keeping the height of traps 1 foot above the crop canopy, spray of methyl demeton 25 EC 0.04% at 30-35 days after germination, two spray of neem seed kernal extract at 45 and 55 days, spray of HaNPV @ 250 L/ha at 65 DAG, two releases of *Trichogramma chilonis* @ 1.5 lac/ha at 75 and 85 DAG, need base spray of conventional insecticides. Results were compared with Non IPM farmer's practices which includes 9-10 spray of insecticides. The farmers were selected in the village and involved in the demonstration and pre seasonal and seasonal farmers field schools. Through which they get acquainted with identification of insect pests, nature of damage, farmers friendly insects. They were trained about the release of *Trichogramma chilonis*, installation of pheromone traps etc.

The observations on the population of sucking insect pests *viz.*, aphids, Jassids, white fly and thrips and bolloworms *viz.*, Spotted bollworm and American bollworm was recorded on 25 plants per ha, 10 ha in IPM and 5 ha in Non IPM fields at weekly interval. Similarly, the observation on the grub and adullt of *Coccinellids*, *Chrysoperla* and Spider was also recorded. The population data were transferred to square root and significance was tested at 5% by the 't' test.

Average damange to square, flower, green bolls and shed material per plant was recorded from 25 plants per ha, 10 ha in IPM and 5 ha in Non IPM. Average damage to open bolls and locule was also recorded in 10 ha in IPM fields and 5 ha in Non IPM on 100 bolls/ha. The percent damage was transferred to Arc Sin transormation and significance was tested by 't' test.

The data on seed cotton yield was recorded separately for IPM and Non IPM fields and were subjected to 't' test.

RESULTS AND DISCUSSION

The incidence of sucking insect pests and bollworms were found to be low in IPM fields during both the season as compared to farmers methods of pesticidal control. The mean data recorded on the sucking insect pests, bollworms and natural enemies, damage to square, flowers, green bolls and shed material/plant, percent boll damage and locule damage and seed cotton yield in IPM and Non IPM fields have been presented in Tables 1 to 4.

Sucking insects

The population of sucking insect pests was comparatively low in IPM field as compared to Non IPM fields. The mean population of aphids (*Aphis gossypii* Glover), Jassids (*Amarsca bigutulla bigutulla* Ishida), White Fly (*Bemesia tabaci* Genna) and Thrips (*Thrips tabaci* Lindeman) in IPM fields was 6.17 and 4.53, 2.17 and 2.82, 3.52 and 3.25, 1.60 and 2.40 against 7.46 and 7.60, 3.53 and 3.60, 5.32 and 3.98 and 2.50 and 3.20 in non IPM per three leaves during 2003 and 2004, respectively (Table 1).

Besides the application of methyl demeton at 30 DAG, the congenial conditions in the IPM

Table 1. Mean population of sucking insect pests and bollworms in IPM and Non- IPM cotton fields

S.No.	Population/plants	2003		2004	
		IPM	Non-IPM	IPM	Non-IPM
1.	Aphids	6.17*	7.46	4.53	7.60
2.	Jassids	2.17	3.53	2.82	3.60
3.	White fly	3.52	5.32	3.25	3.98
4.	Thrips	1.60	2.50	2.40	3.20
5.	*H. armigera eggs*	1.46	2.49	1.33	2.53
6.	*H. armigera larvae*	0.63**	1.00	0.35	0.51
7.	*E. insulana larvae*	0.70	0.97	0.25	0.30
	t test at 5%	Sig.	Sig.	Sig.	Sig

*Average population per three leaves mean of weekly observations

**Average population/plants mean of weekly observations

Table 2. Mean damage of bollworms in IPM and Non-IPM cotton fields

S.No.	Damage	2003		2004	
		IPM	Non-IPM	IPM	Non-IPM
1.	Damage to square by *H. armigera*	3.16*	5.29*	3.93*	9.07
2.	Damage to square by *E. insulana*	5.74	9.02	7.14	11.37
3.	Damage to flower by *H. armigera*	5.65	10.81	3.42	7.60
4.	Damage to flower by *E. insulana*	7.42	15.24	3.83	8.19
5.	Damage to green bolls by *H. armigera*	3.96	7.81	3.52	6.75
6.	Damage to green bolls by *E. insulana*	5.59	15.49	4.77	7.49
7.	Shed material	29.72	33.28	19.40	22.67
8.	Damaged bolls	14.37**	21.41**	24.02**	35.53
9.	Damaged locules	13.64	19.56	26.13	35.46
	t test at 5%	Sig.	Sig.	Sig.	Sig.

*Damage per plants average of weekly observation on 250 plants in IPM & 125 in Non-IPM fields

**Average damage recorded on 100 open bolls/ha, 10 ha in IPM and 5 ha in Non-IPM

Table 3. Mean population of common natural enemies (predators) in IPM and Non-IPM cotton fields

S.No.	Population/plant	2003		2004	
		IPM	Non-IPM	IPM	Non-IPM
1.	*Coccinella* grub*	0.91*	0.59	0.42	0.30
	Coccinella adults	0.76	0.42	1.02	0.62
2.	*Chrysoperla* eggs	1.09	0.61	0.93	0.54
3.	*Chrysoperla* larvae	1.69	0.85	0.77	0.46
4.	*Chrysoperla* adults	1.55	0.80	1.02	0.68
5.	Spiders	0.94	0.54	0.47	0.33
	"t" test	Sig.	Sig.	Sig.	Sig.

*Average of weekly observations/plant

Table 4. Pesticide consumption, seed cotton yield and cost benefit ratio in IPM and Non-IPM fields

S. No.	Village	No. of spray	Quantity of pesticide used		Seed cotton yield			Cost benefit ratio	
			Commercial grade (kg./ha)	a.i. (kg/ha)	2003	2004	Mean	2003	2004
1.	IPM	• 2 Spray of NSKE • 1 Spray of Ha NPV • 2 Insecticidal spray	2.5	0.75-0.85	1918	1804	1861	1:2.63	1:2.33
2.	Non-IPM	8-10 sprays • Endosulfan • Monocrotophos • Rogar • Fenvalerate • Quinalphos	8.0	2.0-2.5	1488	1518	1503	1:1.43	1:1.37

fields provided by planting of three rows of maize intercropped with cowpea around the cotton field encouraged the populaton of *Coccinellids* and *Chrysoperla carnea* which also help in regulating the population of sucking insects in IPM fields.

Bollworms incidence and damage

The population of American bollworm *H. armigera* and spotted bollworm *E. insulana* reduced from 1.00 and 0.97 in Non IPM field to 0.63 and 0.70 per plant in IPM field during the year 2003. The corresponding figures during 2004 were 0.51 and 0.30 in Non IPM and 0.35 and 0.25/plant in IPM field (Table 1). The mean numbers of *H. armigera* eggs were also less in IPM field as compared to the Non IPM fields.

The mean damaged square, flower and green bolls due to *H. armigera* was 3.16 and 3.93, 5.65 and 3.42, 3.96 and 3.52 percent in IPM field as against 5.29 and 9.07, 10.81 & 7.60, 7.81 and 6.75 in non IPM fields during two years, respectively. Similarly, the damage caused by spotted bollworm. *E. insulana* was comparatively low in IPM field as compared to non IPM field during both the years. The observation recorded on shed material revealed that the shed materials *viz.*, fallen flower, buds and bolls was less in IPM fields as compared to non IPM fields (Table 2).

The mean damaged bolls and locutes in IPM fields were 14.37 and 24.02, 13.64 and 26.13 as against 21.41 and 35.53 and 19.56 and 35.46 percent in Non IPM fields during 2003 and 2004, respectively (Table 2).

The installation of sex pheromone traps proved extremely useful for monitoring and timely application of critical inputs, large scale field releases of *T. chilonis* at 1.5 lac/ha against lepidopterous pests and spray of HaNPV @ 250 LE/ha against. *H. armigera* found quite effective which reduced bollworm damage in IPM fields. The effectiveness of these bio-agents has been discussed by Singh, 1994. The reduction in bollworm larvae in IPM fields could also be attributed to growing of *Setaria* in between 9th and 10th row of cotton. Flowering of which coincides with cotton and attract birds which predate upon the larvae of bollworms on cotton crop. The utility of *setaria* as a bird perch has already been reported by Murthy *et al.* (2001).

Natural enemies population

The population of natural enemies *viz.*, Grub and adult of *Coccinellids and Chrysoperla carnea* and the population of spiders was significantly higher in IPM fields as compared to non IPM fields during both the years (Table 3). Population of spiders also showed higher number in IPM fields (0.94 and 0.47/plants) against Non IPM fields (0.54 and 0.33/plants).

The application of IPM components, judicious use of insecticides and also the planting of three rows of maize intervene with cowpea as border crop provided optimum conditions for multiplication and augmentation of natural enemies. It has been reported that neem seed kernel extract is safe to parasitoids and predators. (Tanwar *et al.* 2003).

Seed cotton yield and cost benefit ratio

The mean seed cotton yield in IPM field was significantly higher than the recorded in non IPM fields. The mean seed cotton yield during 2003 and 2004 in IPM fields was 1918 and 1804 kg/ha as against 1488 and 1518 kg/ha in non IPM fields, respectively. The cost benefit ratio in IPM fields was 1:2.63 and 1:2.33 as against 1:1.43 and 1:1.37 in non IPM during 2003 and 2004, respectively. (Table 4). Application of IPM in cotton has finally resulted in a profit of Rs. 7740 and 5148 per ha, respectively, durng two years over non IPM practices. Increases in yield in IPM field over non IPM and effectiveness of IPM technology in cotton has been reported earlier by Singh *et al.* (2002), Tanwar *et al.* (2003) and Ameta *et al.* (2004).

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ANALYSIS OF DIVERSE HYBRIDS FOR STABILITY TO SEED YIELD AND YIELD COMPONENTS IN SUNFLOWER

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Abstract

The stability analysis of 26 hybrids developed with diverse cytoplasmic background over three environments revealed the presence of substantial interaction of the hybrids with environments. Both linear and non-linear compnents are equally important for seed yield, oil yield, oil content and filled seeds. However, the variation in the performance of the hybrids was predictable for days to 50 per cent flowering, days to maturity and 100-seed weight. Based on the environmental indices, *rabi* sowing of sunflower is favoured for the expression of the important characters. In general, the crosses with relatively high yield exhibited low stability indicating that the mean performance and stability are two different components. The hybrid PET-2-7-1 A x R-HR-R-2 was identified as stable hybrid for seed yield, while, PET-2-7-1A x GPA-201-1 was found suitable in favourable environments for seed yield and other components. However, the hybrid PFMS 400 A x 3376 R for oil yield and oil content while, IMS 852 x 856R was suitable for unfavourable environments for oil content and less unfilled seeds.

Key words : Stability, regression, sunflower hybrids.

Sunflower is one of the important oilseed crops of India. Due to its thermo and photo-insensitive nature and buffering capacity it is being cultivated round the year in the different agro-climatic zones. However, the hybrids and breeding material likely to interact differently with different environments. The presently grown sunflower cultivated varieties and hybrids though possesses high seed yield and oil yield potential, they are erratic in their performance even under less varied environmental situations. Apart from the biotic and abiotic stresses, lack of hybrids suitable to specific locations accounts for the decline in the productivity of sunflower. The hybrids exhibited a wide range of variation with respect to their productivity both among themselves and also over the seasons. Therefore, the present study was aimed to evaluate the hybrids for stability though G x E interaction for stability through G x E interaction for seed yield and its components and also to identify appropriate hybrids suitable for specific seasons.

Materials and Methods

The material for the present study comprised of 26 sunflower hybrids derived from diverse cytoplasmic male sterile backgrounds, *H. petiolaris* spp Fallax (PEF), *H. lenticularis* (CMSI), *H. petiolaris* (PET 2) and *H. annuus* L. (PET-1). These hybrids were grown in three environment i.e., summer, 2001 (E-I), kharif, 2001 (E-II) and rabi, 2001-02 (E-III) along with two checks, LBSH-1 and APSH-11 in RBD replicated thrice at College Farm, College of Agriculture, ANGRAU, Hyderabad. Each entry was sown in 3 rows plot of N-60, P-90, K-60 kg/ha. All the recommended package of practices were followed to raise a good crop. Observations were recorded on ten randomly selected plants in all the entries in each replication on days to 50 per cent flowering, days to maturity, head diameter, filled seeds/head, unfilled seeds/head, 100-seed weight, seed yield/plant, oil content and oil yield/plant, respectively. The mean values of these 10 plants were subjected to stability analysis (Eberhart and Russel, 1966).

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RESULTS AND DISCUSSION

The pooled analysis revealed significant differences among the genotypes for all the characters (Table 1). Significant mean squares due to hybrids x environment interaction revealed that the genotypes interacted considerably with the environmental conditions that exists at different seasons. These findings are in agreement with results of earlier workers (Virupakshappa, 1992; Laishram and Singh, 1997 and Prusti *et al.*, 1999). The partitioning of G x E interaction indicated that a substantial portion of variation was linear for days to 50 per cent flowering, days to maturity and 100-seed weight reflecting the predictability of the performance of genotypes over environments (Table 2). Similar results were also reported by Jaivir Singh and Yadava (1982). The results further revealed that non-linear component was important for head diameter and unfilled seeds which indicated the prediction of these traits across environments would be difficult. However, both linear and non-linear components are equally important for filled seeds, seed yield, oil content and oil yield. Similar to the present findings, role of linear and non-linear components for different traits in sunflower were reported by various workers for seed yield, oil content and oil yield (Laishram and Singh, 1997), filled seeds (Jaivir Singh and Yadava, 1983). Contrary to the present findings role of linear component for seed yield was reported by Rana *et al.* (1988). This may be due to differences in the material and environments studies.

The magnitude of environmental indices was positive and high for the characters having significant G x E, probably because of high diversified seasons (Comstock and Moll, 1963). Based on the positive value of environmental indices rabi sowing of sunflower is favoured for the expression of important characters.

Once it is known that genotypes interact with the environment significantly, the next task is to find out the most stable genotypes. The stability parameters, *viz.*, means (x), regression

Table 1. Mean sum of squares in pooled analysis for 12 characters of sunflower in Genotype x Environment interaction studies

Source	d.f.	Days to 50% flowering	Days to maturity	Plan height (cm)	Head diameter (cm)	Steam diameter (cm)	Number of leaves	Filled seeds/head	Unfilled seeds/head	100-seed weight (g)	Seed yield/ plant (g)	Oil content (%)	Oil yield/ plant (g)
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Varictics	25	14.59**++	20.44**++	743.10**++	4.04**	0.06**	9.18**++	27673.50**	1348.77**	0.99**	68.69**	27.40**++	8.72**
Environment + (Varieties x Environment)	52	22.66**++	29.30**++	466.20**++	19.44**++	0.25**++	8.63**++	69331.50**++	1290.33**	1.50**++	372.34++**	8.59**++	57.01**++
Environment (Linear)	1	895.80**++	994.57**++	18538.59++	916.69**++	10.87**++	299.49**++	2402287.50**+	30034,29**++	62,06**++	16393.57**+	124.57**++	2530.00**+
Variety x Env. (Linear)	25	9.05**++	17.66**++	123.38**	1.41	0.04	3.46	25507.32**	474.59**	0.45**++	67.53**	7.35**	10.66**
Pooled deviation	26	2.17	4.62**	100.73**	2.27	0.042	2.39	21741.28**	969.15**	0.18**	49.23**	5.32**	6.45**
Pooled error	156	0.41	0.25	13.42	0.37	0.0036	0.59	393.4	135.8	0.0208	4.79	0.3	0.52

**significant at 1% level against pooled error

++ and + significant at 1% and 5% level respectively against period deviation.

coefficient (bi) and deviation from regression (S²di) were estimated for each hybrid and character separately. Both linear regression (bi) and deviation from regression components of genotype x environment interaction should be considered along with mean while judging the phenotype stability of a genotype which would be expected to perform uniformly well over variable environments. The genotypes exhibiting high regression coefficient (bi>1) could be considered as below average stable genotypes. Such genotypes would perform better in high yielding or favourable environments. However, its performance will be lower in stress environments compared to its genetic potentiality. The genotype with low regression coefficient (bi<1) indicates a genotype to be above average response and which will be specially adapted to low yielding or unfavourable environments.

Development of early maturing hybrids is one of the important breeding objective of sunflower to suit under multiple cropping system. The hybrid PET-2-7-1A x GP-9-201-1 was considered to be a stable hybrid for earliness as revealed from its lower mean (desired for earliness) coupled with a unit regression value (bi-1) and non-significant deviation to varying environmental conditions (Table 3).

In respect of days to maturity, the hybrids IMS-852 A x 856 and PFMS 274A x GP-9-53-2 exhibited lower mean values and these hybrids were suitable only for unfavourable environments, as evident from less than unit regression (bi<1). The remaining hybrids were considered unstable as these hybrids had significant S²di value.

Stability parameter revealed that the hybrids PFMS 274 x GP-9-53-2, PFMS 274 x GP-9-58-4 were found to be stable for head diameter as they had higher mean expression coupled with unit regression coefficient and non-significant deviation from regression. This indicates consistent stability under varied environmental conditions. While, ARM 243A x 6D-IR, PET-2-89A x ARM 2339, PFMS 400A x R272-I, PET-2-89A, GP9-201-1 and PET-2-189A x R-HR-R-2 are suitable for favourable environments. Nevertheless, the hybrid PFMS 274 A x GP9-201-1 recorded high mean value and was found to be

Table 2. Relative contribution of linear and non-linear portion of G X E interaction for different characters in sunflower

S.No.	Character	Linear (%)	Non-linear (%)
1.	Days to 50 per cent flowering	94.17	5.83
2.	Days to maturity	78.6	21.4
3.	Plant height (cm)	54.08	45.92
4.	Head diameter (cm)	35.35	62.65
5.	Stem diameter (cm)	44.37	55.63
6.	Number of leaves	58.34	41.66
7.	Filled seeds per head	53.01	46.99
8.	Unfilled seeds per head	32.01	67.98
9.	100-seed weight (g)	70.55	29.45
10.	Seed yield per plant (g)	56.88	43.12
11.	Oil content (%)	57.04	42.96
12.	Oil yield per plant (g)	61.37	38.63

Table 3. Mean performance and stability parameters of 26 hybrids for 12 characters in sunflower

S.No.	Genotype	Days to 50% flowering			Days to maturity		
		X	bi	S^2di	X	bi	S^2di
1	IMS852A x ARM243	62.56	0.92**	1.28	90.78	1.23**	5.49**
2	IMS852A x 856R	60.22	0.92**	1.28	87.11	0.83**	0.68
3	IMSWGA x 6D-1R	61.33	0.96**	2.79**	89.33	1.12**	4.59**
4	PFMS400A x R272-I	58.22	0.76	6.66**	85.78	0.55	3.95**
5	PFMS400A x R274	61.11	0.16	3.41**	87.67	0.02	2.39**
6	PFMS400A x 3376R	59.44	0.23	4.50**	85.33	-0.13	2.65**
7	PET2-7-1-A x 3376R	61.56	0.22	0.65	87.89	-0.03	14.46**
8	ARM245A x 6D01R	64.67	-0.08	0.91	92.22	0.15	6.09**
9	ARM245A x P356R	60.67	0.63**	2.42*	88.22	0.85*	3.48**
10	ARM245A x 856R	62.56	0.92**	0.28	90.56	0.92*	-0.03
11	ARM245A x 273R	62.00	1.13**	0.55	90.11	1.49**	-0.25
12	302A x R265	60.67	0.92**	1.26	86.78	0.76	7.34**
13	ARM243A x 6D-1R	61.00	0.72**	3.92**	88.78	1.21**	2.68
14	PFMS274A x GP9-53-2	56.00	1.27**	1.53	83.78	0.69**	0.29
15	PFMS274A x GP9-58-4	62.22	1.21**	-0.18	90.33	1.62**	3.92*
16	PFMS274A x GP9-8C-2	58.44	1.73**	0.14	87.00	1.80**	6.23**
17	PFMS274A x GP9-201-1	56.44	0.89**	-0.05	83.11	0.57	5.72**
18	PFMS274A x GP9-58-5	58.44	1.46**	1.34	86.44	1.29**	-0.11
19	PET2-89A x ARM239	63.11	1.87**	0.63	92.00	2.26**	7.46**
20	PET2-89A x GP9-201-1	59.11	1.87**	0.93	88.00	2.14**	9.52**
21	PET2-89A x R-HR-R-2	62.67	1.76**	3.23**	91.22	2.32**	3.06**
22	PET2-7-1A x ARM239	60.00	1.29**	7.46**	88.11	1.65**	0.19
23	PET2-7-1A x GP9-30-1	56.67	1.19**	0.99	84.44	0.94*	2.94**
24	PET2-7-1A x GP9-201-1	56.67	1.05**	0.18	82.89	0.79	1.82**
25	APSH-11	56.67	1.05**	0.17	86.78	0.27	11.38**
26	KBSH-1	59.44	1.22**	0.1	88.67	0.73	7.73**
	General Mean	60.22			87.82		
	Environmental Index						
	SEm+	1.04	0.25		1.52	0.35	
	C.D. (0.05)	1.77		1.39			
	C.D. (0.01)	2.3		1.81			

*significant at 5% level; **significant at 1% level

Contd.......

Contd.......

S.No.	Genotype	Days to 50% flowering			Days to maturity		
		X	bi	S^2di	X	bi	S^2di
1	IMS852A x ARM243	180.38	0.80**	0.19	18.86	1.13	13.07**
2	IMS852A x 856R	138.68	0.14	-8.71	15.37	0.91**	2.01*
3	IMSWGA x 6D-1R	162.92	1.22**	199.96**	15.92	0.71**	0.15
4	PFMS400A x R272-I	149.01	0.80**	15.75	17.99	1.17**	0.06
5	PFMS400A x R274	134.18	0.43	462.04**	14.19	0.99**	0.79
6	PFMS400A x 3376R	150.99	0.42	47.34	16.90	0.98**	-0.01NS
7	PET2-7-1-A x 3376R	146.12	0.97**	5.70	16.59	0.89**	1.35
8	ARM245A x 6D01R	188.07	0.88**	2.53	17.08	1.25**	5.82**
9	ARM245A x P356R	166.6	1.12**	131.63**	16.34	1.14**	1.33
10	ARM245A x 856R	171.46	1.14**	119.49**	16.08	0.89**	-0.23
11	ARM245A x 273R	169.4	1.22	420.54**	15.43	1.29**	6.78**
12	302A x R265	150.6	0.94**	-12.95	15.70	0.63	0.13
13	ARM243A x 6D-1R	182.18	1.47**	12.72	18.11	1.12	-0.35
14	PFMS274A x GP9-53-2	163.08	0.95**	21.55	16.8	1.07**	-0.25NS
15	PFMS274A x GP9-58-4	189.76	1.13	246.39**	16.84	1.07**	-0.25NS
16	PFMS274A x GP9-8C-2	164.47	0.84**	-13.13	15.98	1.16**	0.02
17	PFMS274A x GP9-201-1	139.39	0.67	100.32**	17.01	0.90**	-0.16
18	PFMS274A x GP9-58-5	169.98	1.03**	-7.15	16.86	0.49	3.48**
19	PET2-89A x ARM239	178.29	1.46**	44.13	18.19	1.13**	1.41
20	PET2-89A x GP9-201-1	158.70	1.69**	350.51**	17.41	1.21**	0.88
21	PET2-89A x R-HR-R-2	166.04	1.58**	-10.81	18.61	1.25**	-0.13
22	PET2-7-1A x ARM239	177.38	1.55**	140.42**	16.47	1.13**	1.09
23	PET2-7-1A x GP9-30-1	149.75	0.95**	-8.72	15.51	0.89**	1.31
24	PET2-7-1A x GP9-201-1	145.86	0.43*	28.15	16.02	0.88**	3.95**
25	APSH-11	143.97	0.43*	28.15	16.02	0.88**	3.95**
26	KBSH-1	162.62	1.64**	-13.34	18.47	0.78**	-0.19
	General Mean	161.53			16.72		
	Environmental Index						
	SEm+	7.09	0.38		1.06	0.25	
	CD (0.05)	10.15		1.68			
	CD (0.01)	13.26		2.2			

*significant at 5% level; **significant at 1% level

Contd.......

Contd.......

S.No.	Genotype	Stem diameter			Number of leaves		
		X	bi	S^2di	X	bi	S^2di
1	IMS852A x ARM243	2.11	0.99**	0.0142*	29.89	0.11	-0.23
2	IMS852A x 856R	1.86	0.84**	-0.0004	24.56	0.49	2.03
3	IMSWGA x 6D-1R	2.04	0.95**	-0.0023	25.67	1.02	5.08**
4	PFMS400A x R272-I	1.94	1.14**	0.0021	29.44	0.89**	-0.49
5	PFMS400A x R274	1.62	1.00**	0.0021	29.44	0.89**	-0.49
6	PFMS400A x 3376R	1.89	1.00**	-0.0003	26.67	0.96**	-0.36
7	PET2-7-1-A x 3376R	2.03	0.37**	-0.0034	24.67	0.99**	-0.49
8	ARM245A x 6D01R	2.07	1.25**	0.0189*	26.11	0.43	8.21**
9	ARM245A x P356R	1.9	0.97**	0.0441*	28.49	0.62**	0.29
10	ARM245A x 856R	1.85	1.21**	0.0161*	24.47	0.46	5.19**
11	ARM245A x 273R	1.93	1.04**	0.0006	26.778	1.82**	0.03
12	302A x R265	1.72	0.54**	0.0457**	30.22	2.28**	0.03
13	ARM243A x 6D-1R	1.96	0.88**	0.0079	26.89	0.29**	-0.58
14	PFMS274A x GP9-53-2	1.82	0.60**	-0.0026	28.22	1.09	4.85**
15	PFMS274A x GP9-58-4	1.97	1.14**	-0.0031	29.44	1.5	4.59**
16	PFMS274A x GP9-8C-2	1.61	0.96**	-0.0032	26.78	1.29**	-0.06
17	PFMS274A x GP9-201-1	1.79	0.61**	0.0001	26.44	1.76**	-0.59
18	PFMS274A x GP9-58-5	1.87	1.03**	0.0564**	28.11	0.93	7.27*
19	PET2-89A x ARM239	1.89	1.20**	0.0165*	28	1.19**	-0.56
20	PET2-89A x GP9-201-1	1.92	1.20**	0.0154*	27.89	2.11*	10.61*
21	PET2-89A x R-HR-R-2	2.1	1.56**	-0.0028	29.11	1.38*	0.61
22	PET2-7-1A x ARM239	1.98	1.27**	0.1014**	30	0.79	0.89
23	PET2-7-1A x GP9-30-1	1.97	1.38**	0.3007**	26.78	0.76**	-0.54
24	PET2-7-1A x GP9-201-1	1.84	1.16**	0.0188*	26.62	0.64*	0.15
25	APSH-11	1.86	0.56**	-0.0032	25.67	0.81**	0.1
26	KBSH-1	2.15	0.81**	0.0431*	29.02	0.74**	-0.36
	General Mean	1.91			27.36		
	Environmental Index						
	SEm+	0.14	0.32		1.09	0.46	
	C.D. (0.05)	0.16			2.13		
	C.D. (0.01)	0.2			2.76		

*significant at 5% level; **significant at 1% level

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S.No.	Genotype	Filled seeds per head			Unifilled seeds per head		
		X	bi	S^2di	X	bi	S^2di
1	IMS852A x ARM243	750.48	0.3	102050.89	61.15	1.31**	122.42
2	IMS852A x 856R	576.17	0.35	29669.93*	60.66	-0.67**	-48.26
3	IMSWGA x 6D-1R	624.64	0.52	17154.83*	50.85	1.62**	68.75
4	PFMS400A x R272-I	646.04	0.2	4673.57*	97.73	1.28	1675.06**
5	PFMS400A x R274	489.14	0.29	35708.86*	81.49	1.23	1247.23**
6	PFMS400A x 3376R	602.69	0.73**	409.38	90.06	2.71	8554.79**
7	PET2-7-1-A x 3376R	828.07	0.67**	5435.32*	112.04	0.69**	37.51
8	ARM245A x 6D01R	612.08	1.22**	17837.48*	63.01	0.66	1123.29**
9	ARM245A x P356R	819.5	0.89**	-372.97	56.19	1.64**	-135.76
10	ARM245A x 856R	579.35	0.83**	202.44	76.95	0.98	585.66*
11	ARM245A x 273R	703.45	1.44**	3716/65	75.36	-0.04	-25.92
12	302A x R265	686.8	1.78**	36528.45*	60.57	0.59	366.59
13	ARM243A x 6D-1R	590.4	0.99**	19629.57*	61.5	0.99	1609.16*
14	PFMS274A x GP9-53-2	663	1.23**	11864.60*	53.92	1.03**	153.55
15	PFMS274A x GP9-58-4	660.09	2.07**	4042.74**	75.9	0.82	1097.38**
16	PFMS274A x GP9-8C-2	714.05	1.69**	5298.91**	95.73	1.24**	275.96
17	PFMS274A x GP9-201-1	583.99	1.04**	3829.59**	63.12	0.91**	-135.79
18	PFMS274A x GP9-58-5	743.47	0.49	42433.97*	63.51	0.85**	-135.79
19	PET2-89A x ARM239	667.78	1.08	39457.24*	68.33	1.07**	233.36
20	PET2-89A x GP9-201-1	683.38	1.73**	583.06	98.59	76.57**	
21	PET2-89A x R-HR-R-2	859.24	1.55**	3980.35**	134.78	1.35	1045.23**
22	PET2-7-1A x ARM239	612.26	1.19	119144.69	72.44	0.41**	-133.15
23	PET2-7-1A x GP9-30-1	649.39	0.53	8714.89**	90.3	1.01	2310.66*
24	PET2-7-1A x GP9-201-1	560.33	1.57**	-10.47**	75.19	1.85**	-88.09
25	APSH-11	663.27	1.01	2312.64**	114.86	1.51**	-106.56
26	KBSH-1	875.27	0.58	40847.63*	86.16	0.48	681.88*
	General Mean	670.93			78.78		
	Environmental Index						
	SEm+	104.26	0.49		22.01	0.92	
		C.D. (0.05)	54.95		32.3		
		C.D. (0.01)	71.78				

*significant at 5% level; **significant at 1% level

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S.No.	Genotype	Days to 50% flowering			Days to maturity		
		X	bi	S2di	X	bi	S2di
1	IMS852A x ARM243	5.73	1.02	0.4576**	43.51	0.63	93.09**
2	IMS852A x 856R	4.37	0.8	1.3496**	26.09	0.43	147.13**
3	IMSWGA x 6D-1R	5.04	0.95**	0.0709	32.52	0.69**	39.23**
4	PFMS400A x R272-I	5.39	1.91**	-0.0106	35.95	0.89**	23.82*
5	PFMS400A x R274	4.53	1.08**	0.1176*	23.16	0.51	93.66**
6	PFMS400A x 3376R	4.91	0.69**	-0.0027	30.12	0.67**	0.69
7	PET2-7-1-A x 3376R	3.96	0.83**	0.1304*	32.28	0.75**	47.90**
8	ARM245A x 6D01R	4.10	1.45**	0.2388	28.1	1.26**	26.71*
9	ARM245A x P356R	4.34	1.15	0.0378	37.21	1.12**	-4.68
10	ARM245A x 856R	4.50	1.02**	-0.0194	27.73	0.86**	-3.04
11	ARM245A x 273R	3.47	1	0.7263**	26.88	1.09**	37.94**
12	302A x R265	3.91	0.47**	0.3037**	30.11	1.29**	14.55
13	ARM243A x 6D-1R	4.70	1.42**	0.0918	30.28	1.25**	34.27**
14	PFMS274A x GP9-53-2	4.91	0.72**	0.1064*	34.29	1.08	41.65**
15	PFMS274A x GP9-58-4	4.63	1.24**	-0.0073	29.66	1.32**	4.85
16	PFMS274A x GP9-8C-2	4.28	0.99**	0.1219	36.29	1.73**	-4.62
17	PFMS274A x GP9-201-1	5.14	0.63**	0.0075	31.29	0.94**	-0.29
18	PFMS274A x GP9-58-5	5.62	0.43	0.2671*	41.68	0.54	282.34**
19	PET2-89A x ARM239	4.58	0.38	0.0907*	31.68	0.73	110.44**
20	PET2-89A x GP9-201-1	4.17	0.9	-0.0208	31.08	1.35**	-3.29
21	PET2-89A x R-HR-R-2	4.29	0.25	-0.0208	37.74	0.96**	0.48
22	PET2-7-1A x ARM239	3.53	1.63**	0.0959*	25.71	1.27**	133.57**
23	PET2-7-1A x GP9-30-1	4.74	2.02**	-0.0168	32.27	1.13**	33.56**
24	PET2-7-1A x GP9-201-1	5.36	1.13**	-0.0003	32.8	1.53**	-1.09
25	APSH-11	4.69	0.87**	0.012	32.62	1.01**	0.58
26	KBSH-1	4.50	0.92**	0.522	37.96	0.95**	5.91
	General Mean	4.59			32.31		
	Environmental Index						
	SEm+	0.03	0.28		4.96	0.28	
	C.D. (0.05)	0.39		6.06			
	C.D. (0.01)	0.51		7.91			

*significant at 5% level; **significant at 1% level

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S.No.	Genotype	X	bi	S^2di	X	bi	S^2di
1	IMS852A x ARM243	37.1	-0.78**	-0.02	15.6	0.54	15.30**
2	IMS852A x 856R	41.09	-0.29	10.72	0.42	27.23**	
3	IMSWGA x 6D-1R	39.62	2.37**	2.74**	12.96	0.86**	1.8
4	PFMS400A x R272-I	37.53	-0.51**	-0.19	13.39	0.81**	2.73*
5	PFMS400A x R274	37.52	0.37	2.39**	8.76	0.48	15.10**
6	PFMS400A x 3376R	39.51	0.67	12.37**	12	0.64**	1.38
7	PET2-7-1-A x 3376R	36.5	1.09	1.14	12.7	0.81**	5.58**
8	ARM245A x 6D01R	37.96	0.26	43.27**	11.19	1.35**	9.56**
9	ARM245A x P356R	38.77	1.64	12.56**	14.89	1.35**	-0.04
10	ARM245A x 856R	38.05	0.34	4.24**	10.7	0.89**	0.51
11	ARM245A x 273R	34.65	1.45	6.04**	9.69	1.13**	3.04*
12	302A x R265	35.92	2.09**	0.18	11.28	1.38**	1.59
13	ARM243A x 6D-1R	39.09	-0.54**	-0.3	11.7	1.20**	3.83**
14	PFMS274A x GP9-53-2	33.87	-0.84	4.93**	11.37	0.81**	5.17**
15	PFMS274A x GP9-58-4	30.52	1.89**	0.99	9.35	1.16**	-0.14
16	PFMS274A x GP9-8C-2	36.22	0.69**	0.14	13.29	1.66**	-0.43
17	PFMS274A x GP9-201-1	36	2.04	11.50**	11.46	0.95**	2.32*
18	PFMS274A x GP9-58-5	31.52	1.73**	-0.3	13.17	0.59	19.86**
19	PET2-89A x ARM239	36.1	0.24	5.10**	11.6	0.72	18.81**
20	PET2-89A x GP9-201-1	38.94	0.46	18.15**	11.65	1.25**	0.31
21	PET2-89A x R-HR-R-2	28.36	1.19	2.18**	10.96	0.84**	-0.34
22	PET2-7-1A x ARM239	33.05	4.77**	-0.18	9.67	1.42**	14.49**
23	PET2-7-1A x GP9-30-1	37.57	0.35	4.20*	12.25	1.45**	-0.04
24	PET2-7-1A x GP9-201-1	33.57	0.35	4.20*	12.25	1.19*	4.70**
25	APSH-11	33.23	2.34**	0.19	11.19	1.03**	0.99
26	KBSH-1	39.16	1.28**	-0.17	15.13	1.07**	1.04
	General Mean	36.27		11.87			
	Environmental Index						
	SEm+	1.63	1.05		1.79	0.226	
	CD (0.05)	1.51		1.99			
	CD (0.01)	1.97		2.58			

*significant at 5% level; **significant at 1% level

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Table 4. Stable hybrids for various characters in sunflower

Character	Group-I > X ; bi = 1S^2di = 0	Group-II > X; b>1NS S^2di	Group-III > X; bi<1NSS2di
Days to 50% flowering		PET 2-7-1A x GP9-201-1 PET2-7-1A x GP9-30-1 PFMS274A x GP9-58-5 PFMS274A x GP9-8C-2	PFMS274 x GP9-53-2 PFMS274A x GP9-201-1
Days to maturity			IMS 852A x 856 R PFMS274A x GP9-53-2
Plant height	Dwarf : PET 2-7-1A x 3376R 302A x R265 PET 2-7-1A x GP-9-30-1 Tall : PFMS 274A x GP9-53-2		
Head Diameter	PFMS 274A x GP9-53-2 PFMS 274A x GP9-58-4	ARM243A x 6D-1R PET2-89A x GP9-20101 PET2-89A x ARM239 PET2-89A x R-HR-R-2	
Stem Diameter	IMS WGA x 6DR-1R ARM245A x R273	PFMS 400A x R-272-1 PFMS 274A x GP9-20101 PET2-89A x GP9-20101 PET2-89A x R-HR-R-2	
Number of Leaves	PET2-7 x 3376	302A x R265 PET2-89A x ARM239 PET2-89A x R-HR-R-2	IMS852A x ARM243 PFMS 274A x R272-1 ARM245A x P356R
Filled seeds per head		ARM245A x 273R PET2-89A x GP9-201-1	ARM 245 x P356R
Unfilled seed	PFMS 274A x GP9-53-2 PET2-89A x ARM239	IMS WGA x 6DR-1R IMS852A x ARM243	IMS 852 x 856R PFMS274A x GP9-201-1 PFMS274A x GP9-58-5
100 Seed weight	PRMS274A x GP9-8C-2	PFMS400A x R272-1 ARM243A x 6D-1R PFMS 274A x GP9-58-4 PET 2-7-1A x GP-9-30-1 PET 2-7-1A x FP-9-201-1	PFMS 400 A x 3376R
Seed yield	PET2-89A x R-HR-R-2 KBSH - 1	PFMS274A x GP9-8C-2 PET 2-7-1A x GP-9-201-1	
Oil Content	PET 2-7-1A x 3376 R		IMS852A x ARM243 IMS 852A x 856R ARM243A x 6D-1R
Oil Yield	KBSH-1	ARM 245A x P356 R PFMS274A x GP9-8C-2 PET 2-7-1A x GP-9-201-1	IMS WGA x 6D-1R PFMS 400A x 3376R

Group - 1 : High mean average response and stable under all environments.
Group - 2 : High mean and suitable for favourable environments.
Group - 3 : High mean and suitable to unfavourable environments.

adaptable to less favourable environments as reflected by their regression value less than unity and non-significant deviation.

The hybrids, ARM 245A x 273R and PET-2-89A x GP9-201-1 exhibited higher number of filled seeds and below average stable (bi>1) performance i.e., under the most favourable environments they perform better than other hybrids. Most of the hybrids exhibited unstable performance.

For unfilled seeds, hybrids with low mean values were considered as desirable. The hybrids, PFMS 274A x GP-9-53-2 and PET-2-89A x ARM 239 were designated as highly stable hybrids, whereas IMS WGA x 6D-IR and IMS 852A x ARM 243 were observed to perform better under favourable environments only. While IMSWGA x 956, RPFMS 274A x GP9-201-1 and PFMS 2274A x GP9-58-5 were suitable to poor environments as indicated by recording less mean and above average stability.

For test weight, none of the hybrids exhibited high mean with stability. However, the hybrids PRMS 400 A x R-272-I, ARM 243A x 6D-IR PFMS 227A x GP9-58-4, POET-2-7-1A x GP-9-30-1 and PET-2-7-1A x GP9-201-1 were found to be highly sensitive to environmental fluctuations for test weight and these hybrids were specially suitable for favourable environments.

Seed yield being a quantitative character it fluctuates considerably with the change in environments. The stability in seed yield results from genetic homeostasis due to compensation among component character over variable environments. Nevertheless, in the present study, the hybrids which had relatively high mean seed yield possessed moderate stability i.e., the mean performance was inversely proportional to stability. All the three stability parameters estimated for seed yield revealed that the seed yield of PET-2-89A x R-HR-R-2 and KHSH-1 were significantly higher than that of other hybrids with stable performance over environments. It can be inferred that the hybrids PFMS 274A x GP-9-80-2 and PET-2-7-1A x GP-9-201-1 were stable and high yielders and exhibited regression coefficient more than unity suggesting that these hybrids could perform well under high yielding environments.

For oil content, the hybrid, PET-2-7-1A x 3376R was found to be highly stable while IMS 852A x ARM 243, IMS 852A x 856R and ARM 243 A x 6D - 1R were suitable to tailored environments by exhibiting bi value more than unity and non-significant deviation from regression. For oil yield, IMS WGA x 6D-1R and PFMS 400 A x 3376 R had high mean value with above average stability (bi<1) and were found to be suitable for poor environments. On the other hand, ARM 245A x P 356R, FPMS 274A x GP9-80-1 and PET-2-7-1A x GP-9-201-1 though performed superior like standard check KBSH-1 for mean oil yield, however, showed stable performance under favourable environments.

Considering the overall performance, the expression of stability appeared to be specific for individual character of genotype and was not common for all the characters (Table 4). The hybrid, PET-2-89A x R-HR-R-2 was identified as stable hybrid for seed yield while, PET-2-7-1A x GP-9-201-1 was stable for earliness and suitable in favourable environment for seed yield, oil yield and 100-seed weight. For poor environments, the hybrids IMS 852A x 856R performed better better for oil content less unfilled seeds and earliness while PFMS 400 A x 3376 R for oil yield and oil content. These hybrids can be tested at different locations to test their performance and stability before recommending for release and general cultivation.

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EFFECT OF DRIP IRRIGATION AND MULCHES ON GROWTH AND YIELD OF BELL PEPPER (*CAPSICUM FRUITESENS* L.)

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ABSTRACT

A field study was conducted on a gravelly sandy loam soil in the Agricultural College Farm, Rajendranagar, Hyderabad, Andhra Pradesh, India during *rabi* 2001-02 to study the effect of drip irrigation at three levels of water application *i.e.*, at 1.0, 0.8 and 0.6 of maximum evapotranspiration and surface irrigation in combination with two mulches *viz.*, black polythene and paddy husk on growth and yield of bell pepper. For surface irrigation, 40 mm depth of water was given at IW/CPE ratio of 1.00. Plants irrigated through drip on an average were taller at harvest by about 5.5 cm compared to those received surface irrigation. Plant height was more in black polythene mulch (47.3 cm) followed by paddy husk (42.3) and was least in unmulched (35.6) plots. The average dry matter produced was higher in drip irrigation treatments compared to surface irrigation throughout the growth period. It was highest in black polythene mulch followed by paddy huxk and was lowest in unmulched plots throughout the crop growth period. drip irrigation, in general, recorded significantly higher green fruit yield compared to surface irrigation. Among the irrigation treatments, highest yield was recorded in drip 1.0 followed by drip 0.8 and drip 0.6 which were statistically at par. Black polythene mulch was found to be superior (9.6 t ha^{-1}) to paddy husk mulch (8.68 t ha^{-1}) and no mulch (7.88 t ha^{-1}) treatments. Among all the treatments, highest yield was obtained with drip 0.8 and black polythene mulch combination and lowest was recorded in surface irrigation without mulch. The use of drip either alone or in combinaation with mulching was better over surface irrigation.

Key words : Drip irrigation, mulches, yield, bell pepper.

Water is increasingly becoming scarce because of erratic distribution of monsoons and uncontrolled exploitation of ground water. The scarce water resource in the country necessitates its judicious use which will be possible by efficient water management practices like drip method. Major advantages of drip irrigation over furrow irrigation are improved water application efficiency and precision placement with drip irrigation. Mulching was found to reduce evaporation losses of water from soil apart from other advantages like reduced weed problem, maintaining thermal regime in the root zone etc. (Bhella, 1988). In the recent years, plastic mulches of different colours are coming up in place of organics, particularly in high value crops under intensive cultivation. However, adequate data on the effect of drip irrigation in combination with mulches of different materials is not available specially with vegetable crops like bell pepper the area of which is increasing around Hyderabad. Keeping this in view, the present investigation was taken up to study the effect of drip irrigation and mulches on growth and yield of bell pepper.

MATERIALS AND METHODS

The experiment was conducted during *rabi* season of 2001-02 in the Agricultural College Farm, Rajendranagar, Hyderabad. The soil was red sandy loam having adequate drainage, the properties of which are given in Table 1.

Six weeks old seedings of bell pepper, *Capsicum fruitesens* var. California Wonder were transplanted. The experiment was laid out with the following 12 treatmental combinations of 4 irrigations and 3 mulches viz.,

T_1 = Drip irrigation at ETa = ETm with no mulch (drip 1.0),
T_2 = Drip irrigation at ETa = 0.8 ETm with no mulch (drip 0.8),
T_3 = Drip irrigation at ETa = 0.6 ETm with no mulch (drip 0.6),
T_4 = Surface irrigation with no mulch (S.I.),
T_5 = T_1 + Black polythene mulch (drip 1.0 + BM),
T_6 = T_2 + Black polythene mulch (drip 0.8 + BM),
T_7 = T_3 + Black polythene mulch (drip 0.6 + BM),
T_8 = T_4 + Black polythene mulch (S.I. + BM),
T_9 = T_1 + Paddy husk mulch (drip 1.0 + PH),
T_{10} = T_2 + Paddy husk mulch (drip 0.8 + PH),
T_{11} = T_3 + Paddy husk mulch (drip 0.6 + PH),
T_{12} = T_4 + Paddy husk mulch (S.I. + PH),

Where ETa = Actual evapotranspiration (mm) and ETm = Maximum evapotranspiration (mm)

Table 1. Soil properties of the experimental site

S.No.	Parameter	Value
1.	Soil reaction (pH)	7.18
2.	Electrical conductivity (dS m^{-1})	0.55
3.	Particle size distribution (%)	
	Sand	88.0
	Silt	10.0
	Clay	2.0
	Gravel (%)	23.5
	Textural class	Gravelly sandy loam
4.	Bulk density (Mg m^{-3})	1.42
5.	Porosity (%)	44.50
6.	Wet aggregate analysis :	
	Mean weight diameter (mm)	1.1
	Aggregates > 0.25 mm (%)	63.32
7.	Water retention (%)	
	At 0.1 bar	14.19
	At 15 bar	4.55
8.	Organic carbon (%)	0.48

The drip system consisting of main, submain and laterals were laid out in the plots as per the treatments. Separate valves were fixed to the submains for providing different drip irrigation treatments. For surface irrigation treatments, water was discharged with pipe line into the plots. In the plots where drip treatments were adopted, the laterals were laid along the crop rows at 60 cm distance and drippers were fixed on the laterals at 45 cm spacing (close to the plant) as per the spacing of the crop. The dripper discharge was 4 litres per hour. End plugs were fixed to all main, sub main and laterals to facilitate maintenance of the system. Irrigations were given based on evapotranspiration to meet the crop water requirement for entire crop period. Irrigations were given on alternate days in drip irrigation treatments. At IW/CPE (irrigation water per cumulative pan evaporation) ratios of 1.0, 0.8 and 0.6 with the help of controlling valves. In case of surface irrigation treatment, 40 mm of water was given when the cumulative pan evaporation reached 40 mm. The total quantity of irrigation water given was 15.88 ha-cm in drip 1.0, 12.71 ha-cm in drip 0.8 and 9.53 ha-cm in drip 0.6 and 28 ha-cm in surface irrigation treatment. Irrigation treatments were imposed at 30 days after transplantation.

The polythene mulch (black) and organic mulch (paddy husk) were laid after establishment of the crop. Black polythene mulch film of 25 micron thickness was cut into pieces of 5.5 m x 50 cm to cover 80 per cent of the area in the main field. Before laying the film, small circular holes were made with scissors as per the intra row spacing (45 cm) of the crop and the sheet was spread on the crop rows by carefully taking out the established plants through the holes made already above the lateral pipe. Then the sides of the polythene film were anchored with soil. Organic mulch with paddy husk at the rate of 2.5 kg per one square metre was spread in the treatment plots uniformly covering the entire plot.

Plant height was recorded at 15 days interval starting from sowing to 75 days after transplantation (DAT) and at harvest. Dry matter production was recorded at 55 and 75 DAT and at harvest (108 DAT) by collecting 5 hills from each plot and is expressed in kg ha^{-1}. Green fruits were picked 5 times and the total yield was reported as t ha^{-1}.

RESULTS AND DISCUSSION

Plant height

Plant height ranged between 12.5 and 15.5 cm at 30 DAT (Table 2). There was no specific trend until 30 DAT as the treatments were not

Table 2. Effect of drip irrigation and mulches on plant height (cm)

Treatment	Days after transplantation					At harvest
	15	30	45	55	75	
Drip 1.0	11.6	14.1	20.8	25.3	29.8	42.1
Drip 0.8	11.2	13.7	20.0	24.9	29.4	42.3
Drip 0.6	11.0	13.3	19.0	24.1	30.3	42.2
Surface irrigation	11.0	13.0	18.7	23.4	27.9	36.7
		Mean over irrigations				
Black mulch	11.3	13.7	19.9	25.5	31.5	44.2
Paddy husk	11.0	13.7	19.9	24.3	27.3	40.2
Unmulched	11.4	13.1	19.1	23.6	29.2	38.1

imposed. The effect of mulches and irrigations on plant height was significant from 55 days onwards. The data indicated that plants in plots with drip were taller by about 5.5 cm compared to those in the plots with surface irrigation at harvest. In drip irrigation, soil water content was maintained at higher level throughout the crop growth period which might have facilitated full cell elongation reflecting in the height. However, there was no difference in plant height within the drip treatments. Plant height was highest in black polythene mulch treatment (47.3 cm) followed by paddy husk mulch (42.3) and least in unmulched (35.6) plots. These results are in confirmation with findings of Bhella (1988).

Dry matter production

It ranged from 46.2 to 114.1, 373.2 to 592.6 and 691.2 to 1037.2 kg ha^{-1} at 55 at 75 DAT and at harvest, respectively. Significantly higher dry matter production was observed in drip irrigation (averaged over 3) treatments compared to surface irrigation throughout the growth period which was 84.5 and 57.1 kg ha^{-1} at 55 DAT, 482.9 and 390.8 kg ha^{-1} at 75 DAT and 898.7 and 749.2 kg ha^{-1} at harvest in plots with drip and surface irrigation, respectively. This might be due to the maintenance of high soil water content uniformly throughout the growth period unlike in surface irrigation wherein fluctuations in soil water content were experienced by the plant. Goldberg *et al.* (1976) and Beese *et al.* (1982) have reported similar findings.

Dry matter production was 90.7, 76.5 and 65.8 at 55 DAT; 513.4, 545.1, 432.9 at 75 DAT, 941.5, 870.1, 772.5 kg ha^{-1} at harvest in plots with black polythene mulch, organic mulch and no mulch, respectively. Mulching resulted in higher dry matter production (by 37 per cent in polythene mulch and 15 per cent in paddy husk) compared to unmulched treatment at 55 DAT. At harvest, it was higher by 22 and 12 per cent with black polythene and paddy husk mulches over no mulch. These results agree with those of Elfving (1982). The interaction between irrigation i.e., either drip or surface and mulching was not significant.

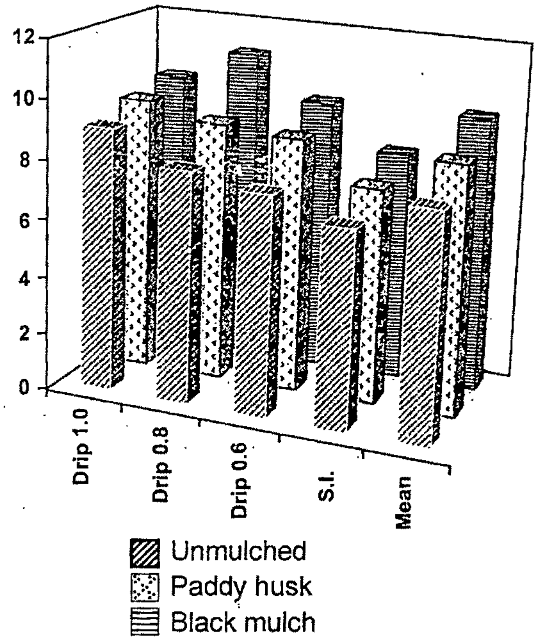

Fig. 1. Effect of drip irrigation and mulches on green fruit yield (t/ha) of bell pepper

Green fruit yield

It ranged from 6.83 (S.I. with no mulch) to 10.94 (drip 0.8 + BM) t ha^{-1} and the data is depicted in Fig. 1. drip irrigation resulted in significantly higher yields compared to surface irrigation. The increase was 27, 25 and 16 per cent with drip 1.0, drip 0.8, drip 0.6 with 9.47, 9.32 and 8.64 t ha^{-1}, respectively over surface irrigation (7.46 t ha^{-1}). This might be due to maintenance of optimum soil moisture in the crop root zone with drip irrigation. Thimme Gowda and Gocoda (1990) also reported similar results. Further, the results showed that mulching recorded higher yields by 21.7 per cent with black polythene and 10.2 per cent with paddy husk over no mulch treatment (7.9 t ha^{-1}). The increase in yield due to mulches might be due to favourable soil physical environment in the root zone (Omran *et al.* 1995). From the study, drip irrigation was found to be better in terms of growth and yield of bell pepper over surface irrigation. However, there was no significant difference within the drip treatments. Mulching increased the yield over no mulch. Black polythene mulch was found to be better over paddy husk mulch.

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INFLUENCE OF VARIOUS PHOSPHATIC SOURCES ON YIELD AND YIELD COMPONENTS OF WHEAT

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ABSTRACT

Field experiment was conducted during *rabi* season of 2002-03 and 2003-04 at Indian Agricultural Research Institute, New Delhi to see the response of various phosphatic sources in the form of chemical fertilizers and biofertilizers on yield and yield components of wheat (cv. HD 2285). The field experiment was conducted in randomized block design. There were twelve treatments with various phosphatic sources applied singly or in combination with nitrogen. All these treatments were replicated thrice. The yield components of wheat crop were favourably affected by $N_{120}SSP_{30}$ VAM in 2002-03 and by $N_{120}RP_{30}$PSB in 2003-04. In wheat, the highest grain yield of 59.56 q/ha was recorded in treatment $N_{120}SSP_{30}$VAM in 2002-03, and in 2003-04 the highest value of 60.32 q/ha was observed in $N_{120}RP_{30}$ PSB.

Key words : Phosphatic source, yield components, wheat.

With the discovery of several deposits of rock phosphate (RP) in the country, interest in the use of this indigenous material as alternative phosphatic fertilizers has increased greatly. Although RP can effectively replace water solube phosphates in acid soils, but its efficiency in netural, alkaline and calcareous soils is extremely low. To make it effective in such soils it is being converted into water soluble form by mixing with SSP or by partial acidulation with mineral acids, for which sulphur is being imported. In all these cases, the underlying principle is to supply acid for conversion of insoluble P of RP into soluble P. In this context, biofertilizers like phosphate solubilizing bacteria (PSB) and vesicular arbuscular mycorrhiza (VAM) can prove effective.

Nutrient management has played a crucial role in achieving self sufficiency in food grain production. Energy crisis resulted into high price index of chemical fertilizers coupled with their limited production, fertilizer cost, soil health, sustainability and pollution have led to a renewed interest in the use of alternative nutrient sources of which use of biofertilizers is worth mentioning. The nutrient requirement of a crop is met by the external application of chemical or biofertilizers as soil amendment, seed/soil inoculation with biofertilizer or by foliar application.

MATERIALS AND METHODS

A field experiment in randomized block design (RBD) with twelve treatments and three replications was conducted during 2002-04. The treatments were - T_1 : SSP_{60}; T_2: RP_{60}; T_3: N_{120}; T_4: N_{120} P_{60}; T_5: PSB; T_6: VAM; T_7: N_{120} PSB; T_8: N_{120} VAM; T_9: N_{120} SSP_{30} PSB; T_{10}: N_{120} SSP_{30} VAM and T_{11}: $N_{120}RP_{30}$PSB; T_{12} RP_{30} VAM. The wheat variety HD 2285 was used in the experiment.

RESULTS AND DISCUSSION

The treatment $N_{120}SSP_{30}$ VAM recorded the highest number of ear/m^2 (325.33) in 2002-03, while, in next year N_{120} RP_{30} PSB recorded the highest value (340.33). In both the years, the lowest value was associated with RP_{60}. Significant increase in number of spikes/m^2 were observed in N_{120} RP_{30} PSB, N_{120} RP_{30} VAM while treatments SSP_{60}, RP_{60}, N_{120}, PSB, VAM, N_{120}VAM experienced lowered number of spikes/m^2.

During 2002-03, the highest test weight of 45.39 g was observed in N$_{120}$SSP$_{30}$ VAM, but the value recorded against N$_{120}$ P$_{60}$, N$_{120}$ VAM, N$_{120}$ SSP$_{30}$ PSB, N$_{120}$SSP$_{30}$ VAM, N$_{120}$RP$_{30}$PSB, N$_{120}$RP$_{30}$ VAM were not significantly different from each other. During 2003-04, treatments N$_{120}$ P$_{60}$, N$_{120}$ SSP$_{30}$ PSB, N$_{120}$ SSP$_{30}$ VAM, N$_{120}$ RP$_{30}$ PSB, N$_{120}$ RP$_{30}$ VAM were statistically at par.

During the years, treatments N$_{120}$ P$_{60}$, N$_{120}$ SSP$_{30}$ PSB, N$_{120}$ SSP$_{30}$ VAM, N$_{120}$ RP$_{30}$ PSB, N$_{120}$ RP30VAM gave statistically at par values of number of grains/ear. The highest number of grains/ear (49.00) in 2002-03 and (52.33) in 2003-04 were associated with N$_{120}$ SSP$_{30}$ VAM and N$_{120}$ RP$_{30}$ PSB respectively.

During both the years, the treatments N$_{120}$ SSP$_{30}$ VAM and N$_{120}$ RP$_{30}$ PSB were statistically at par. However, during 202-03, the highest grain yield of 59.56 q/ha was recorded in treatment N$_{120}$ SSP$_{30}$ VAM while in 2003-04, the highest value of 60.32 q/ha was recorded in N$_{120}$ RP$_{30}$ PSB. During 2003-04, the treatment N$_{120}$ RP$_{30}$

Table 1. Effect of treatments on yield components of wheat in *rabi* 2002-03 and 2003-04

Treatment	No. of ears/m^2			Test weight (g)			No. of grains/ear		
	2002-03	2003-04	Pooled	2002-03	2003-04	Pooled	2002-03	2003-04	Pooled
SSP$_{60}$	253.00^{i+}	249.00^{g}	249.50	43.24^{bc}	43.04^{bc}	43.14	37.00^{c}	34.67^{f}	35.84
RP$_{60}$	244.67^{k}	239.33^{h}	242.00	42.51^{cd}	42.32d	42.42	38.00^{dc}	36.00^{f}	37.00
N$_{120}$	269.00^{h}	262.33^{f}	265.67	43.84^{b}	43.71^{b}	43.78	41.00^{cd}	40.00^{de}	40.50
N$_{120}$P$_{60}$	312.33^{c}	312.33^{d}	312.33	44.90^{a}	45.00^{a}	44.95	47.00^{a}	48.67^{ab}	47.84
PSB	248.67^{j}	245.33^{g}	247.00	42.47^{d}	32.80^{c}	42.77	38.33^{dc}	37.00^{ef}	37.67
VAM	250.67^{ij}	242.67^{gh}	246.67	43.12^{c}	42.61^{cd}	42.87	38.67^{dc}	36.33^{ef}	37.50
N$_{120}$PSB	277.00^{g}	280.00^{c}	278.50	44.00^{b}	44.15^{a}	44.08	42.67^{bc}	45.33^{bc}	44.00
B$_{120}$VAM	282.67^{f}	279.00^{c}	280.84	44.17^{a}	44.12^{b}	44.15	43.00^{bc}	42.00^{cd}	42.50
N$_{120}$SSP$_{30}$PSB	304.33^{d}	316.00^{d}	310.17	44.76^{a}	45.08^{a}	44.92	45.33^{ab}	49.33^{a}	47.33
N$_{120}$SSP$_{30}$VAM	325.33^{a}	332.33^{b}	328.83	45.39^{a}	45.45^{a}	45.42	49.00^{a}	51.67^{a}	50.34
N$_{120}$RP$_{30}$PSB	321.00^{b}	340.33^{a}	330.67	45.21^{a}	45.48^{a}	45.35	48.33^{a}	52.33^{a}	50.33
N$_{120}$RP$_{30}$VAM	296.00^{c}	323.00^{c}	309.50	44.63^{a}	45.15^{a}	44.89	45.33^{ab}	50.00^{a}	47.65
SEm±	1.10	1.44		0.44	0.44		1.20	1.19	
CD (P = 0.05)	3.21	4.23		1.28	1.30		3.53	3.52	

+Within a column, means followed by the same letter are not significantly different at the 0.05 level of probability by Duncan's Multiple Range Test (DMRT)

CVAM was statistically at par with N_{120} SSP_{30} VAM. The lowest grain yield of 36.92 q/ha and 33.59 q/ha was recorded in 2002-03 and 2003-04 respectively in treatment RP_{60}. The grain yield registered a decline over previous year in treatment SSP_{60}, RP_{60}, N_{120}, PSB, VAM, N_{120} VAM, while it improved in rest of the treatments. The pooled value of wheat grain yield indicated the superiority of N_{120} SSP_{30} VAM (Table 2).

During 2002-03 the stover yield (Table 2) of N_{120} P_{60}, N_{120} SSP_{30} VAM, N_{120} RP_{30} PSB were statistically at par while the highest value of 80.78 q/ha was recorded in treatment N_{120} SSP_{30} VAM. During 2003-04, the highest treatment was associated with N_{120} RP_{30} PSB (84.55 q/ha) and it was statistically at par with that of N_{120} SSP_{30} PSB, N_{120} SSP_{30} VAM, N_{120} RP_{30} VAM. The highest pooled value of 81.55 q/ha was associated with treatment N_{120} SSP_{30} VAM. During both the years the treatment RP_{60} recorded the lowest stover yield. In treatment SSP_{60}, RP_{60}, N_{120}, PSB, VAM, N_{120} VAM, the stover yield decreased in 2003-04.

In 2002-03, the harvest index (Table 2) value varied from the lowest value of 0.39 observed in treatments SSP_{60}, PSB, VAM to the highest value of 0.43 observed in treatment N_{120} SSP_{30} VAM. During 2003-04, the lowest value of 0.37 was recorded in PSB, while the highest value of 0.43 was recorded in N_{120} SSP_{30} VAM. The treatments SSP_{60}, RP_{60}, PSB, VAM were statistically at par and the rest treatments were also statistically at

Table 2. Effect of treatments on yield and harvest index of wheat

Treatment	Grain yield (q/ha)			Stover yield (q/ha)			Harvest index		
	2002-03	2003-04	Pooled	2002-03	2003-04	Pooled	2002-03	2003-04	Pooled
SSP_{60}	40.44^{f*}	37.99^{f}	39.22	63.88^{f}	61.66^{dc}	62.77	0.39^{bc}	0.38^{b}	0.385
RP_{60}	36.92^{g}	33.59^{h}	35.26	58.21^{h}	55.21^{g}	56.71	0.39^{bc}	0.38^{b}	0.385
N_{120}	44.61^{c}	43.44^{c}	44.03	67.55^{c}	64.30^{d}	65.93	0.40^{abc}	0.41^{a}	0.405
$N_{120}P_{60}$	55.49^{bc}	55.58^{c}	55.54	78.69^{ab}	79.44^{b}	79.07	0.41^{ab}	0.42^{a}	0.415
PSB	38.59^{fg}	36.05^{fg}	37.32	60.65^{gh}	60.50^{ef}	60.58	0.39^{c}	0.37^{b}	0.380
VAM	39.74^{f}	35.68^{gh}	37.71	62.72^{fg}	58.17^{f}	60.45	0.39^{c}	0.38^{b}	0.380
N_{120}PSB	48.99^{d}	50.54^{d}	49.77	69.68^{dc}	71.62^{c}	70.65	0.42^{ab}	0.42^{a}	0.420
B_{120}VAM	49.78^{d}	49.37^{d}	49.58	71.29^{d}	69.81^{c}	70.55	0.41^{abc}	0.42^{a}	0.415
$N_{120}SSP_{30}$PSB	55.08^{c}	57.50^{bc}	56.29	76.50^{bc}	81.56^{ab}	79.03	0.42^{a}	0.42^{a}	0.420
$N_{120}SSP_{30}$VAM	59.56^{a}	60.22^{a}	59.89	80.78^{a}	82.31^{ab}	81.55	0.43^{a}	0.43^{a}	0.430
$N_{120}RP_{30}$PSB	57.43^{ab}	60.32^{a}	58.88	79.46^{a}	84.55^{a}	82.01	0.42^{a}	0.42^{a}	0.420
$N_{120}RP_{30}$VAM	54.94^{c}	59.24^{ab}	57.09	75.32^{c}	82.85^{a}	79.09	0.42^{a}	0.42^{a}	0.420
SEm±	0.76	0.73		0.95	1.00		0.008	0.006	
CD (P = 0.05)	2.24	2.14		2.78	2.94		0.024	0.017	

*Within a column, means followed by the same letter are not significantly different at the 0.05 level of probability by Duncan's Multiple Range Test (DMRT) par among themselves.

Among the different yield components of wheat, the number of ears/m^2 was highest in N_{120} SSP_{30} VAM in 2002-03 and in N_{120} RP_{30} PSB in 2003-04. However, other yield components like test weight and number of grains/ear did not vary significantly among treatments involving N_{120} along with SSP_{30} or RP_{30} in presence of PSB or VAM. The superiority of treatments N_{120} SSP_{30} VAM in 2002-03 and that of N_{120} RP_{30} PSB in 2003-04 in terms of number of ears/m^2 might have been responsible for higher grain and stover yield in treatments N_{120} SSP_{30}VAM and N_{120} RP_{30} PSB during both the years. Comparing T_7 (N_{120} PSB) and T_8 (N_{120} VAM) it was observed that slight yield reduction occured in N_{120} VAM in 2002-03 while slight yield increase was observed in N_{120} PSB. This may be justified from the fact that in absence of addition of any phosphatic fertilizer sources, the P mobilizers i.e. VAM might have mobilized all the available P sources and after two maize and one wheat crop most probably very little available P sources would have left over.

But on the other band, the PSB gradually release organic acids to solubilize insoluble inorganic and organic P sources and thus bring more of the unavailable P sources into the available P pool. Thus depletion of available P sources might have occurred to lesser extent in treatments involving PSB. The greater P availability might have triggred better root growth, nutrient uptake and finally better yield components and higher grain yield. However, during 2002, the VAM inoculated treatments resulted in better yield components and yield than PSB inoculated treatments. The results are in conformity with the findings of Zaghloul *et al.* (1996) and Chhabra and Jalali (1997). The beneficial effect of PSB on yield and yield attributes of wheat was also reported by Israel (1991).

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GENETIC DIVERGENCE IN INDIAN MUSTARD

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Precise information about the extent of genetic divergence and on characters used for discrimination among population is crucial in any crop improvement programme. The existence of heterosis in a hybrid usually demonstrates the existence of some degree of genetic diversity. Therefore, the nature and magnitude of genetic divergence and the characters contributing to genetic diversity were studied among forty-three genotypes of Indian mustard using D^2 statistic.

In the Robi seasons of 1999 (E_1) and 2000 (E_2), 13 homozygous diverse lines and their 30 F_1 hybrids derived from a 10x 3 linex tester mating design were evaluated in randomized block design with 3 replication. Each genotype was grown in single row, each 5 m long, with a spacing of 30 cm between rows and 10 cm between plants. Observations were recorded on five random plants of each genotype in a replication for plant height, primary branches, secondary branches, main shoot length, siliquae on main shoot, siliqua length, seeds/ siliqua, 1000-seed weight, seed-yield/plant and oil content. Days to 50% flowering and days to maturity were recorded on plot basis. Genetic divergence was studied by Mahalanobis's generalized distance (D^2) analysis (Rao, 1952).

Based on divergence analysis, the genotypes were grouped into six and 15 clusters, respectively and the highest number of genotypes were included in cluster I in both the environments (Table 1). Single genotype was observed in three clusters in environment I (E_1) and in two clusters in environment II (E_2). In the present study, parents and their hybrids failed to appear in the same cluster but contrarily scattered among different cluster as the findings of Singh *et al.* (1981), Yadav *et al.* (1985). Such behaviour of F_1's in relation to their parents may be explained on the basis of genetic interaction among parental genes. In cluster II of environment I (E_1), 3 hybrids alone with RH-30, as a parent was there. That showed a close affinity of the hybrids with one of the parent. It may be due to dominance of genes from such parent. The constituents of each cluster were not the same in two environments. Upadhya and Murty (1970) in pearl millet and Somayajulu *et al.* (1970) in wheat, opined the importance of favorable environment to enable a genotype to fully express various characters for classification based on genetic diversity as estimated by D^2 statistic. The shift in cluster constituents from environment to environment casts doubt on the reliability of D^2 analysis in a single environment and suggest the need of making such studies under multiple environmental conditions.

The intra-cluster distances were almost equal and relatively lower than the inter cluster distances (Table 2). The inter cluster distances varied from 9.87 between cluster I and II to 22.60 between III and IV in E1. Higher inter cluster distances were recorded between IV and VI (19.33), II and V (19.45), IV and V (18.44) and I and VI (17.35). In E_2, the inter cluster distances vary from 6.42 between cluster VI and XV to 24.44 between XV and X. Appreciably higher inter cluster distances were also recorded between X and VI (24.35), X and IX (24.13), IV and VIII (21.80), XV and XII (21.75), X and V (20.88) XIII (20.32), XIV and VIII (20.18), XIII and X (23.67), XIII and XI (20.07) and VIII and VII (20.07).

The clusters differed from each other for one or more characters. The cluster mean values for different characters are presented in Table 3. In environment I (E1), cluster III with genotypes RH-9615xRWH-1 and RH-9621xRWH -1 exhibited les number of days to flowering, high oil content, high main shoot length; cluster II with less number of days to maturity and plant height; cluster IV with genotype RH-9404x

Table 1. Distribution of 43 genotypes of Indian mustard in different cluster

Cluster	Number of genotypes	Genotypes included in cluster
Environment I (E_1)		
I.	29	RH-9624 x RH-30, RH-9707xRH30, RH9707xT6342 RH-9609x RH 30, RH-9624xT-6342, RH-9710xRWH-1, RH-9621xRH-30, RH9621xT-6342, RH9710xRH-30, RH-9513xRWH-1, RH9617xT6342, RH-9710xT-6342, RH-9707xRWH-1, RH-9608xRH-30, RH-9609xRWH-1, RH-9617xRWH-1, RH-9621, RH-9624xRWH-1, RH9615x T-6342, RH-9513xT-6342, RH-9404, RH9404xRWH-1, RH-9624, RH-9609xT-6342, RH-9608xRWH-1, RH-9608, RH-9707, RH-9404xT-6342, RH-9608xT-6342.
II.	9	RH-9609, RH-9617xRH-30, RH-9513, T-6342, RH-9710, RH-9615xRH-30,RH-30 RH-9615, RH-9513xRH-30.
III	2	RH-9615xRWH-1, RH-9621xRWH-1
IV	1	RH-9404xRH-30
V	1	RWH-1
VI	1	RH-9617
Environment II (E_2)		
I	9	RH-9707, RH-9513, RH-30, RH-9513xT-6342, RH-9404x T-6342, RH-9624xT-6342, RH-9617xT-6342, RH-9621xRWH-1
II	3	RH-9621xRH-30, RH-9617xRWH-1, RH-9624xRH-30
III	5	RH9608xT-6342, RH-9717,
IV	2	RH9608xT-6342, RH-9717,
V	2	RH-9615xRWH-1, RH-9710xRWH-1
VI	4	RH-9613xRH-30, RWH-1, RH-9609xRWH-1, RH-9710
VII	3	RH-9609xT-6342, RH-9710xT-6342, RH-9609
VIII	3	RH-9621, RH-9404xRH-30, RH-9404xRWH-1
IX	2	RH-9608xRH-30, RH-9609xRH-30
X	2	RH-9615xT-6342, RH-9621xT-6342
XI	2	RH-9624xRWH-1,RH-9707xRH-30
XII	2	RH-9608, RH-9608xRWH-1
XIII	2	RH-9513xRWH-1,RH 9707xT-6342
XIV	1	RH-9615xRH-30
XV	1	RH-9624

RH-30 exhibited high primary and secondary branches. In environment II, Cluster II with the genotype, RH-9404xRH-30, RH-9617xRWH-1, RH-9624xRH-30 exhibited high seed-yield; cluster IV with the genotypes RH-9608xT-6342 exhibited high 1000-seed weight and siliqua length; cluster V with hybrids RH-9615 x RWH-1 and RH-9710 x RWH-1, exhibited high seeds/siliqua and siliquae on main shoot. Cluster III with the hybrids, RH-9710xRH-30, RH-9513xRH-30, RH-30, RH-9707xRWH-1 exhibited less number of days to maturity.

Days to 50% flowering (10.42%, 8.91%), days to maturity (23.80%, 22.64%), plant height (31.02%, 31.54%), primary branches (0.99%, 0.91%), secondary branches (2.31%, 1.92%), main shoot length (11.29%, 12.88%), siliquae on main shoot (6.83%, 7.77%), siliqua length (0.64%, 0.68%), seeds/siliqua (1.93%, 1.97), 1000-seed weight (0.84%, 0.79%), seed-yield/plant (4.42%, 3.47%) and oil content (6.27%, 6.48%) contributed to total divergence in varietal improvement programme.

Table 2. Intra and inter cluster distances (D) in 43 genotypes of Indian mustard

Environment I (E_1)

	1	2	3	4	5	6
1	7.14	9.87	10.26	11.71	14.76	17.35
2	0	6.98	15.47	13.81	19.44	11.51
3		0	8.11	10.53	14.69	22.60
4			0	0	18.43	19.33
5					0	26.15
6						0

Environment I (E_2)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	4.44	8.20	8.28	13.77	12.46	10.19	9.54	17.86	13.74	15.01	14.42	7.86	18.98	7.37	8.87
2		1.52	1091	15.42	9.8	7.04	12.58	13.54	13.41	19.35	18.66	7.99	20.42	11.60	7.55
3			4.40	12.79	13.54	10.47	9.23	17.88	11.54	17.41	9.80	10.16	18.72	9.58	7.55
4				1.18	15.22	15.74	10.31	21.80	7.24	11.83	14.82	13.86	17.06	10.50	17.57
5					1.52	8.10	15.05	13.28	6.78	20.86	15.98	6.98	12.33	15.04	9.42
6						4.92	10.84	12.58	7.96	24.35	19.79	7.47	18.61	13.77	6.42
7							3.31	20.07	7.94	13.17	16.79	10.99	18.20	9.63	9.07
8								5.02	17.66	24.13	19.92	12.80	20.32	20.18	8.58
9									3.17	17.99	19.70	9.53	15.62	8.21	12.02
10										3.34	18.77	19.73	23.67	9.76	24.44
11											4.45	19.75	26.07	13.14	19.60
12												4.90	18.42	8.48	9.77
13													6.24	16.50	21.75
14														0	15.44
15															0

Table 3. Cluster mean for various characters in Indian mustard

Cluster	Days to 50% flowers	Days to maturity	Plant height (cm)	No. of primary branches	No. of sec. branches	Main shoot length (cm)
Environment I (E_1)						
I	59.45	140.38	196.61	6.25	12.80	77.30
II	57.33	138.48	175.33	4.97*	9.60	75.64
III	54.67*	147.17	223.38*	6.65	21.77	80.97
IV	61.33	149.67	190.07	7.63**	24.39**	77.07
V	102.67	154.33**	220.52	7.27	14.53	45.47*
VI	62.33	148.00	177.73	5.20	4.87	75.60
C to D^2	10.42	23.80	31.02	0.99	2.31	11.29
Environment II (E_2)						
I	55.03	139.77	192.28	5.43	10.25	80.89
II	51.56	144.44	213.84	6.40	14.43	92.48**
III	56.93	136.67*	197.27	5.98	12.97	82.38
IV	60.33	147.67	192.23	5.17	9.72	88.22
V	63.17	152.34	223.45	6.38	14.78	82.72
VI	65.92**	147.17**	207.41	6.78**	14.43	70.18*
VII	53.78	139.78	170.30	5.62	10.93	77.67

VIII	58.33	144.89	212.48	6.25	15.19**	77.96
IX	51.17	141.50	183.21*	5.38	11.69	84.14
X	48.33*	146.83	192.22	5.49	9.56	87.57
XI	51.17	141.50	183.21*	5.38	11.69	84.14
XII	63.00	143.67	213.84	6.25	14.17	79.05
XIII	53.84	140.67	215.28	5.92	12.72	77.11
XIV	52.00	145.00	185.00	5.67	9.22	85.55
XV	60.33	146.67	193.64	4.43*	8.31*	79.89
C to D2	8.91	22.64	31.54	0.91	1.92	12.88

Cluster	Siliquae on main shoot	Siliqua lengh (cm)	Seeds/siliqa (cm)	1000-seed weight (gm)	Seed-yield /plant (gm)	Oil content (%)
Environment I (E_2)						
I	46.54	4.18	11.76	4.96	26.18	4.02
II	41.62	4.26	11.53	6.23	19.65	39.44
III	52.78**	4.27	12.66	4.45	35.16	41.74**
IV	42.33	2.80	13.09**	5.71	46.39**	39.17
V	43.57	3.40*	12.07	2.77*	24.05	41.52
VI	34.00*	5.55**	12.63	7.97**	24.05	41.52
C to D2	6.83	0.64	1.93	0.84	4.42	6.27

Cluster	Siliquae on main shoot	Siliqua lengh (cm)	Seeds/siliqa (cm)	1000-seed weight (gm)	Seed-yield /plant (gm)	Oil content (%)
Environment II (E_2)						
I	48.99	4.15	12.02	5.34	20.20	40.55
II	51.42	4.64	14.05	4.78	27.81**	42.19
III	48.71	4.32	12.21	5.63	23.19	41.37
IV	45.25	4.92**	12.35	6.71**	20.42	39.40*
V	56.00**	4.59	14.31**	4.67	25.92	42.37
VI	48.66	4.38	13.47	4.94	20.32	40.83
VII	46.92	4.14	12.23	4.96	19.50	41.49
VIII	48.25	4.72	13.71	4.84	27.57	40.46
IX	45.89	4.10	12.74	5.22	21.97	41.13
X	47.28	4.51	12.27	5.13	22.45	39.42
XI	57.23	3.98	11.07*	4.68	24.63	41.66
XII	53.78	3.90	11.08	4.84	17.85*	41.19
XIII	51.45	4.02	12.94	4.64	21.73	42.64**
XIV	43.00*	4.06	12.08	4.93	18.01	41.33
XV	47.60	4.24	11.36	4.50*	19.87	41.42
C. to D2	7.77	0.68	1.97	0.79	3.47	6.48

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EFFECT OF DIFFERENT NITROGEN SOURCES ON RADIAL GROWTH AND DRY MYCELIAL WEIGHT OF *PLEUROTUS DJAMOR* (FR.) BOEDIJN

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Mushrooms are large reproductive structures of edible fungi belonging to either *Ascomycotina* or *Basidiomycotia*. The mushroom comprise a large heterogenous group having various shapes, sizes, colour, all quite different in characters, appearance and edibility. Of this large group with more than 2000 edible species about 300 species belonging to 70 genera are reported from India. Mushrooms are a sources of good quality protein and are rich in vitamins of B-complex including folic acid and vitamin B_{12}. As a low calorie high protein item with negligible starch and sugars, these are the delight of the dibetic, very high potassium, sodium ratio, low calorie and fat (rich in linoleic acid and lacking of cholesterol) make mushroom the choice of the dietician for those suffering with obesity, hypertension and heart disease.

The research work was carried out at the Mushroom Research Laboratory, Department of Plant Pathology, Indira Gandhi Agricultural University, Raipur. The pure culture of *Pleurotus djamor,* was procured from Department of Microbiology, Rajendra Agricultural University, Samastipur, Bihar. All the experimental data was analysed as per Completely Randomised Design (CRD) with equal replications. The critical differences were assessed at 5% probability. Tested seven different nitrogen sources i.e. ammonium sulphate, L-asparagine, peptone, potassium nitrate, sodium nitrate, tryptophan and urea were supplemented @ 100 ppm in the basal medium. Control treatments were not supplemented with nitrogenous source. Each treatment was replicated thrice. The petriplates and flasks were inoculated with a 3mm disc of young culture of *P. djamor,* incubated for 7 and 15 days respectively at 25±1°C. Observations were recorded for radial growth and dry mycelial weight.

Effect of nitrogen sources on radial growth and dry mycelial weight of *Pleurotus djamor* was studied. The results are presented in Table 1, clearly shows the retardation of radial growth in different treatments as compared to control, however, addition of different nitrogen sources in the liquid media reversed the trend and control showed the least dry weight of the mycelium. Among the different nitrogen sources there was significant difference in radial growth and dry mycelial weight of *P. djamor*. The radial growth of *P. djamor* was highest (85.00 mm) in P.D.A. i.e. without nitrogen source, however, statistically it was at par with ammonium sulphate (79.16 mm), urea (77.50mm), L-asparagine (76.66mm) and potassium nitrate (70.83mm). The radial growth was least (50.83mm) when the P.D.A. medium was supplemented with sodium nitrate. In contrast to above results control showed the lowest dry mycelial weight than rest of the treatments. Supplementation with potassium nitrate recorded the highest dry mycelial weight and it was significantly higher than supplementation with ammonium sulphate, peptone, L-asparagine, tryptophan and control, and the differences were at par with urea and sodium nitrate. Although P.D.A. alone showed lowest dry mycelial weight it was statistically at par with L-asparagine and tryptophan.

The results of the investigation indicate that among the different nitrogen sources tested none could promote the growth of *P. djamor* on solid media. Among the nitrogen sources tested ammonium sulphate, urea, L-asparagine and potassium nitrate were at par with unsupplemented control. Ammonium sulphate and urea as best nitrogen source have also been reported by Mani and Marimuthu (1994). Kapoor *et al.* (1997) have also reported that the urea and

Table 1. Effect of different nitrogen sources on radial growth and dry mycelial weight of *P. djamor*

Nitrogen sources*	Radial growth** (mm)	Dry Mycelial weight** (g)
Ammonium sulphate	79.16	0.77
L-asparagine	76.66	0.73
Peptone	66.66	0.75
Potassium nitrate	70.83	0.85
Sodium nitrate	50.83	0.79
Tryptophan	55.83	0.70
Urea	77.50	0.84
P.D.A. (Control)	85.00	0.68
C.D. at 5%	16.38	0.074

* Basic ingredient potato + agar in solid media and only potato in liquid media

** Average of three replications

asparagine are the best sources of nitrogen for *P. fossulatus*. Srivastava and Bano (1970) reported ammonium nitrate and asparagine as best for *P. flabellatus*. Khanna and Garcha (1958) found peptone as best source for *P. sajor-caju* and *P. ostreatus* and asparagine for *P. sapidus*.

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INHERITANCE OF SCENT IN LONG GRAINS RICE GENOTYPES

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Scent is an important economic trait in rice for local consumption as well as export purposes. Long grain scented rice fetch high premium in both domestic and international markets. However, its share for export is less than five percent due to low productivity of scented rice. The options are limited to increase the yield of scented rice, however hybrid technology might be useful to develop heterotic scented rice hybrids by using superior parents regarding to their quality. If a dominant gene for scent is identified in long grains varieties that can be used to develop scented rice hybrids with acceptable grain quality, by using long grains non-scented cytoplamic male sterile (CMS) lines, because of producing long grains rice hybrids required both the parents of long grains (Khush *et al.* 1988). Scent in rice is genetically controlled and its genetic behaviour were reported by earlier workers, namely Kadam and Patankar (1938) and Bijral and Gupta (1998) who reported that scent is governed by a single dominant gene, whereas Sood and Siddique (1978) reported its monogenic recessive inheritance. Similarly other workers, Tripathi and Rao (1979) ; Tsuzuki and Shimokawa (1990); and Geetha (1994) reported complementary, inhibitory and duplicate gene interaction, respectively for expressing scent in rice. Mostly scent in aromatic rices is controlled by a single recessive gene but its dominant form was also identified in some rice varieties.

The lack of consistency among the results of various earlier workers concerning to genetic behaviour of scent suggested that genes responsible for this character may differ with scented varieties (Tsuzuki and Shimakawa, 1990). Hence, for this possibility an attempt was made in present study to identify a single dominant gene in long grain rice genotypes.

The experimental material comprised a long grains non-scented cytoplasmic male sterile (CMS) line, IR58025 A (Kernel length -7.53mm) and three long grains scented rice genotypes, *viz.*, Hawn Kikwai (KL-7.75mm), Gopal Bhog (KL-6.51 mm) and PB-5-14-50-1 (KL-7.18mm). These genotypes were crossed with same cytoplasmic male sterile line, IR 58025 A during Kharif, 2001 at Agricultural Research Farm, Banaras Hindu University, Varansi and resultant F_1 's of all the crosses and their F_2's were studied for inheritance pattern of scent at the same research farm during *Kharif*, 2002 and 2003, respectively. Aroma was detected from leaves of individual plants by using standaed method of Nagaraju *et al.* (1991). At tillering stage, 2 g of leaves collected from individual F_1 and F_2 plants, which were chopped into small pieces and put into stoppered vials containing 10 ml of 1.7% KOH solution heated at 50°C for 4 to 5 minutes in the oven. They were then opened one by one and a panel of five judges scored scent by smelling flavour from open vials whose unanimous response of 4

Table 1 : Inheritance of scent in three rice crosses

S.No.	Cross	F_1	No. of F_2 Plants S	NS	X^2 value	Genetic ratios
1.	IR 58025 A x Hawn Kikwai	NS	88	312	1.92	1:3
2.	IR 58025 A x Gopal Bhog	NS	40	160	2.66	1:3
3.	IR 58025 A x PB -5-14-50-1	NS	109	291	1.08	1:3

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out of 5 (80% agreement) were taken as conclusive. The samples were classified into two categories scented and non-scented in the presence or absence of aroma.

All the F_1 plants of these crosses showed non-sented leaves indicating recessive nature of gene for controlling scent in rice. The evaluation of scent in F_2 plants indicated 1 scented : 3 non-scented seggegation in all the crosses (Table 1) suggesting that scent in these rice genotypes are governed by a single recessive gene. Since these rice genotypes contain a single recessive gene for aroma, hence pedigree method can be useful to select superior genotypes for yield and quality characters in F_1 and subsequent generations.

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EFFECT OF SOWING DATES AND WEED CONTROL METHOD ON PRODUCTIVITY OF WHEAT (*TRITICUM AESTIVUM* L.) IN UTTARANCHAL

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Wheat (*Triticum aestivum* L.) is often delayed due to the late harvesting of paddy, sugarcane ratoon and potato. There may be different weed flora and weed infestation, requiring varying agronomic practices particularly weed control for optimum yield of wheat crop. *Phalaris minor* is the dominating weed of wheat crop. The losses caused by this weed may range from 30-80% (Brar and Singh, 1997). The use of isoproturon has stabilized the production of wheat by shiedling at least a quarter loss in potential yield of wheat (Malik and Singh, 1993). Due to resistance developed in *Phalaris minor* against isoproturon various herbicides are being tested. Efforts in this direction can be made by manipulating the date of sowing, use of new herbicides and time of application (pre-emergence, post-emergence). Keeping in view all these factors and paucity to information about integrated management of *Phalaris minor* and other weeds, the present study was planned to see the effect of date of sowing in relation to different herbicides application against *Phalaris minor* in wheat crop.

The experiment was laid out in split plot design during rabi season of 2002 at Crop Research Centre of G.B. Pant University of Agriculture & Technology, Pantnagar. Three dates of sowing (November 15, November 30 and December 15) were kept in main plots and different weed control treatments (weedy, two hand weeding, isoproturon @ 1.0 kg ha^{-1}, sulfosulfuron @ 30 g ha^{-1}, metribuzin @ 175 g ha^{-1} and pendimethalin @ 1.5 kg ha^{-1}) in sub plot were replicated three times. Wheat cv. UP 2425 was sown as per treatments using 100 kg seed ha^{-1} at 23 cm row spacing. Experimental soil was silty clay loam in texture, high in organic carbon (0.86%), medium in phosphorus (1.5 kg ha^{-1}), potassium (125 kg ha^{-1}) having pH 7.3. Crop was raised as per recommended package of practices.

Phalaris minor among grasses, *Anagallis, arvensis, Chenopodium album, Fumeria parviflora,* and *Cornopus dedymus* among non-grasses were major weeds. *Cyperus rotundus* was the only sedge in experimental plot. Other weeds comprised of minor population of *Melilotus spps, Vicia sativa, Polygonum plebejium, Lathyrus aphaca* and *Cynodon dactylon.* Among all the weeds *Phalaris minor* was the major weed. *Phalaris minor* population was influenced significantly by date of sowing and weed control treatments at 60 DAS. Singh *et al.* (1997) also reported the similar results. *Phalaris minor* population was the highest in November 15 sown crop which was significantly higher over rest of the two dates (November 30 and December 15). *Phalaris minor* population was reduced significantly in the treatments of two handweedings (30 and 60 DAS) and in sulfosulfuron 30 g ha^{-1} treated plots. *Anagallis arvensis* was controlled completely by metribuzin 175 g ha^{-1}. Significantly lower population of *Anagallis arvensis* was recorded in pendimethalin 1.5 kg ha^{-1} treated plots and significantly higher population was recorded in November 15, sown crop. The similar trend was also noticed in case of rest of the weeds, which were also higher in November 15 sown crop than November 30 and December 15 sown crop. *Chenopodium album* was controlled completely in treatments of pendimethalin 1.5 kg ha^{-1} metribuzin 175 g ha^{-1} and isoproturon 1.0 kg ha^{-1}. The density of *Fumeria parviflora* was significantly lower in sulfosulfouron 30 g ha^{-1} over weedy check. *Coronopus dedymus* was not influenced significantly by date of sowing. Metribuzin controlled *Coronopus dedymus* completely however, the population of Coronopus dedymus was reduced significantly over weedy check. *Cyperus rotundus* was not affected significantly

Table 1. Weed dry matter (g m^{-2}) weed control efficiency (WEC%), grain yield, and B :C ratio influenced by various treatment

Treatment	Total weed dry matter	Weed Control Efficiency (WEC %)	Grain yield (q ha^{-1})	B:C ratio
Date of sowing				
November 15	2.47 (18.8)	55.2	39.2	1.73
November 30	2.02 (10.54)	56.0	40.8	1.77
December 15	2.24 (11.33)	51.5	30.6	1.23
CD at 5%	0.37	-	2.4	-
Weed control measures				
Weedy	3.55 (38.18)	0.0	28.8	1.29
Two hand weeding (30 + 60 DAS)	1.24 (2.85)	74.0	40.1	1.75
Isoporturon 1.0 kg ha^{-1}	2.30 (10.3)	59.5	36/9	1.75
Sulfosulfuron 30 g ha^{-1}	1.93 (6.10)	73.7	39.2	1.47
Metribuzin 175 g ha^{-1}	2.36 (13.56)	68.3	36.6	1.63
Pendimethalin 1.5kg ha^{-1}	2.29 (10.4)	64.0	36.2	1.41
CD at 5%	20.57	-	1.9	-

by dates of sowing but the population was reduced by pendimethalin 1.5 kg ha^{-1}. Thus, combined effect were seen on total weed population. Significantly higher population of total weeds was found in November 15 sown crop than November 30 or December 15 sown crop. Total weed population was significantly lower in all the weed management plots than weedy check. Weed population was almost similar in all the weed control treatments. The weed dry matter was reduced resignificantly by various herbicidal treatments than weedy check. Lowest weed dry matter (2.85 g m^{-2}) was recorded in two hand weeded plots, followed by sulfosulfuron 30 g ha^{-1} (6.10 g m^{-2}). Weed dry matter was at par in rest of the treatments (Table 1). Weed dry matter was lesser as reflected by weed control efficiency (WEC%) in two hand weeded plots followed by sulfosulfuron 30 g ha^{-1} (73.7%).

Grain yield was significantly higher in November 30 sown crop as compared to December 15. Reduction in grain yield was highest (28.2%) in weedy check and lowest (2.40%) in sulfosulfuron (30 g ha^{-1}) treated plots. Chhokar and Malik (2002) also found similar results. The higher yields were associated with grain size, number of spikes and grains per spike. The grain yield was higher in two hand weeded plots but the B:C ratio was higher (1.75) in isoproturon 1.0 kg ha^{-1} treatment plots. This was associated with higher cost of labours in two hand weeded plots and costly herbicide (sulfosulfuron). Metribuzin 175 g ha^{-1} also gave the higher B:C ratio than rest of the herbicidal treatments. Grain yield of wheat was reduced drastically after November 30. Thus, on the basis of one year observations it may be concluded that wheat should be sown up to November 30 for hgher yields and weeds may be controlled by isproturon (1.0 kg ha-1) for higher net reruns if the problem of resistance is not detected so far.

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EFFECT OF TILLAGE AND NITROGEN LEVELS ON GROWTH AND YIELD OF MAIZE (*ZEA MAYS* L.)

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Maize (*Zea mays* L.) is the stape food for millions of people of the world. Maize crop has a good potential under Punjab conditions but high cost of cultivation, weed problems and sensitivity to water lodging (because of monsoon season) are the major constraints. The cost of cultivation can be decreased to a great extent by judicious use of nitrogenous fertilizer and by adopting suitable tillage levels. Keeping this in view, present research was planned during *kharif*, 2002 at Department of Agriculture, Khalsa College, Amritsar. The soil was sandy loam, medium in organic carbon with pH 8.2. Available nitrogen, phosphorus and potassium were 185 kg/ha, 18.11 kg/ha and 192 kg/ha, respectively. Maximum temperature, minimum temperture, mean sunshine, maximum relative humidity and total rainfall were recorded as 37.7°C, 16.9°C, 7.75hrs/day, 83%, 44% and 484mm, respectively, during crop season. Experiment was designed in split plot with four replications, three levels of tillage i.e. zero tillage (by using no-till drill), minimum tillage (one ploughing followed by one planking), minimum tillage (one ploughing followed by one planking) and conventional tillage were taken in main plot treatments. Whereas, five nitrogen levels (0, 80, 100, 120 and 140kg/ha) were taken as sub-plots treatments. Various growth and yield attributing factors (viz.plant height, cobs per plant, cob length, grains per cob and 1000 grain weight) were observed. Harvest index was worked out by using the following formula :

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Data on different levels of tillage did not indicate any significant difference for growth, yield attributing characters, grain yield, stover yield and harvest index. Maximum grain yield of 39.5q/ha was recorded in conventional tillage,

Table 1. Growth, yield attributes and yield of maize as influenced by various levels of tillage and nitrogen

Treatment	Plant* height (cm)	Cobs/ plant	Length of cob (cm)	Grains/ cob	1000 grain wt. (g)	Grain yield (q/ha)	Over yield (q/ha)	HI (%)
Tillage levels								
No-tillage	161.89	1.04	17.78	282.3	285.65	37.97	75.84	33.2
Minimum tillage	165.94	1.05	18.04	292.55	287.25	38.25	77.48	32.2
Conventional tillage	167.56	1.15	18.55	296.89	289.50	39.56	81.28	32.1
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen levels (kg/ha)								
0	131.85	0.79	12.37	213.07	197.33	27.79	69.80	28.40
80	147.65	0.96	14.98	247.32	239.75	36.14	74.84	32.53
100	170.22	1.02	18.94	305.04	308.83	41.08	79.52	33.20
120	186.57	1.25	20.83	341.14	342.33	43.36	81.87	34.62
140	189.37	1.29	22.52	346.37	349.08	44.59	83.96	34.62
CD (P=0.05)	10.58	0.16	2.32	16.11	15.4	2.98	3.89	1.39

* Plant height at harvest

which was only numericaly different to other treatmetns. But the cost of cultivation was less in case of no tillage, as compared to other tillage treatmetns. These results are similar to ones reported by Sharma (1991). Further, all growth and yield attributes were greatly influenced by levels of nitrogen. Application of 80, 100, 120 and 140kg N/ha gave 36, 14, 41.08, 43.36 and 44.36 q/ha of grain yield, respectively, but difference between 120 kg N/ha and 140 kg N/ha was not significant (Table 1). All nitrogen treatments gave significantly higher stover yield than 0 kgN/ha. These results are similar to reports of Paradkar and Sharma (1993).

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GENETIC VARIABILITY IN INDIGENOUS COTTON (*GOSSYPIUM ARBOREUM*) OF NORTH EASTERN REGION

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Cotton is an important fibre crop of N.E. Region of India. Indigenous cotton mainly *arboreum* is grown by the local tribes under *jhum* (slash and burn method) cultivation as mixed crop with several other crops in this region. A number of different *arboreum* cultivars are grown having wide range of variability for various morpho-physiological traits including both biotic and aboitic stresses. However, these cultivars are facing eminent danger of extinction due to gradual deletion of the crop by the farmers for various reasons, out of which, low cotton price and inadequate marketing facilities are important (Anon, 2002). Hence, there is an urgent need for collection, evaluation and maintenance of these cultivars for future breeding perspectives. The present work was, therefore, undertaken to collect and evaluate *arboreum* cotton cultivars of N.E.Region of India.

An itinerary was prepared for cultivation of *arboreum* cotton of N.E. Region. Farmers field was taken as a unit area and random samples from the population were also collected from the farm stores (Pandravada *et al.* 1996). Germplasm were labeled properly with suitable accession numbers and grown during kharif 2001 to 2003 using Randomised Block Design with three replication. Data recorded for five important traits were subjected to assess genetic variability and its related parameters viz., genotypic co-efficient of variance (GCV), phenotypic coefficient of variance (PCV), heritability in broad sence (h^2bi) and genetic advance (GA) as percentage of mean using standard formulae of Panse and Sukhatme (1967), Johnson *et al.*, (1955) and Allard (1960).

Analysis of variance indicated sufficient variability in the material under study. A wide range of mean performances were recorded for all the traits (Table 1). Seed cotton yield per plant ranged from 5.55 to 14.54g/plant. The maximum plant height of 206.6 cm was exhibited in Garo Kill and Phelo Chanpong-2 with a plant height of 206.6 and 197.3 cm, respectively. Number of bolls/plant ranged from 5.0 to 17.9 bolls/plant in Mizo white 2 and Phelosaw-1, respectively. The cultivar Phelosaw 1 exhibited the maximum number of bolls/plant (17.9bollsd/plant). The ball weight was maximum in Garo Kil 2, Phelopisa, Garo I, Karbi and Garo Kill 3 with a boll weight of 3.99, 3.89, 3.7g, 3.6g and 3.6g, respectively. The highest seed cotton yield/plant was exhibited by Karbi (11.54g/plant).

The genotypic and phenotypic variances were high in plant height and number of bolls/plant (Table 2). High GCV (%) and PCV (%) were recorded for number of branches/plant (31.19% and 31.39%, respectively) and seed cotton yield/plant (39.45% and 40.56%, respectively. All the traits exhibited high heritability (in broad sense) ranging from 82.00% in days to flower to 94.94% in ball weight (g). It revealed that the phenotypic selection for these traits would be more efficient. High genetic advance along with high heritability was observed in number of balls/plant (90.93% and 107.62%, respectively) and seed cotton yield/plant (94.59% and 79.04%, respectively). It indicated that these traits are predominantly governed by additive gene interaction and thus revealed the importance of phenotypic selection for these traits. Tomer and Singh (1991) also observed moderate to high estimate of genetic variation, heritability and genetic advance for bolls/plant, seed cotton yield/plant and seed yield/plant in 83 genotypes of tree cotton (*G. arboreum*). High genetic variation for seed

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Table 1. Mean performance of indigenous *arboreum* cotton germplasm (2001-02 to 2003-04)

Accession No.	Days to flower				Plant height (cm)				No. of balls/plant				Ball weight (g)				Yield/plant (g)			
	2001	2002	2003	Mean	2001	2002	2003	Mean	2001	2002	2003	Mean	2001	2002	2003	Mean	2001	2002	2003	Mean
AAYAC 01101	75.0	79.3	81.0	78.4	144.0	158.0	158.7	153.6	17.0	13.0	18.0	16.0	3.7	3.2	3.8	3.6	14.35	14.64	14.75	14.58
AAYAC 01102	85.0	87.3	84.3	85.6	141.3	140.7	158.7	151.7	11.0	11.0	14.7	12.2	3.9	3.3	3.9	3.7	10.1	10.50	11.46	10.66
AAYAC 01103	74.0	75.0	74.0	74.3	140.7	142.3	151.0	144.7	16.0	14.3	16.0	145.4	3.2	2.8	3.4	3.1	9.66	9.69	11.91	10.42
AAYAC 01104	75.3	76.3	78.0	76.6	120.7	122.7	126.7	123.3	19.0	17.0	17.7	17.9	3.2	2.8	3.3	3.1	9.53	9.57	10.02	9.71
AAYAC 01106	74.0	73.0	74.0	77.9	132.3	135.0	144.0	137.1	6.7	7.3	8.7	7.6	3.5	2.9	3.2	3.2	8.40	8.49	8.73	8.54
AAYAC 01107	78.3	77.3	78.0	77.9	125.3	128.3	134.3	129.3	5.7	6.7	9.7	7.3	2.6	2.5	2.9	2.6	5.64	6.18	7.09	6.30
AAYAC 01108	76.0	76.0	74.7	75.6	150.3	150.3	148.7	149.8	9.3	9.3	13.7	10.8	4.1	3.3	4.0	3.8	7.11	7.17	7.69	7.32
AAYAC 01109	69.3	70.0	75.7	71.7	119.3	124.7	130.3	124.8	23.7	14.0	13.3	17.0	3.1	2.8	3.1	2.9	11.49	11.16	11.69	11.45
AAYAC 01110	78.7	78.0	78.3	78.3	145.0	149.0	142.0	145.3	12.0	11.7	14.3	12.7	3.2	2.8	3.3	3.1	8.24	8.28	8.73	8.42
AAYAC 01111	75.0	75.7	75.0	75.2	135.0	135.7	146.0	138.9	9.3	9.3	12.3	10.3	3.2	2.8	3.3	3.1	5.29	6.15	7.50	6.32
AAYAC 01112	75.0	74.7	78.0	75.9	129.3	132.0	134.0	131.8	15.0	14.0	11.0	13.3	2.8	2.5	3.1	2.8	8.39	8.58	8.28	8.45
AAYAC 01114	81.7	81.0	84.0	82.2	197.7	191.7	202.7	197.3	4.3	7.0	12.7	8.0	3.7	2.9	3.4	3.3	5.52	6.18	8.07	6.59
AAYAC 01116	75.3	74.3	74.7	74.8	205.0	204.7	210.0	206.6	11.0	10.7	10.3	10.7	3.6	2.9	3.2	3.2	10.06	10.14	9.96	10.05
AAYAC 01117	76.3	76.0	76.0	76.1	155.3	156.3	166.7	159.4	9.7	10.0	11.3	10.3	3.8	2.9	3.8	3.5	9.12	9.30	9.48	9.30
AAYAC 01118	77.0	76.3	77.7	77.0	137.7	140.3	146.7	141.6	9.7	10.3	9.0	9.7	4.2	3.2	4.2	3.9	9.12	9.15	9.57	9.28
AAYAC 01119	77.0	77.0	80.7	78.2	130.7	134.7	147.0	137.4	11.0	10.7	16.3	12.7	4.0	3.2	3.7	3.6	10.08	10.02	12.45	10.85
AAYAC 01121	86.0	87.3	84.7	86.0	136.0	138.3	134.0	136.1	8.0	8.3	5.3	7.2	2.1	2.1	2.3	2.2	5.76	5.88	5.76	5.80
AAYAC 01123	84.0	87.7	83.3	85.0	123.0	130.0	135.0	129.3	4.0	5.7	5.3	5.0	2.2	2.1	2.3	2.2	5.10	5.88	5.70	5.56
Mean	77.4	77.9	78.4	77.9	142.7	146.1	146.6	146.5	11.2	10.6	12.2	11.3	3.3	2.8	3.3	3.2	8.49	8.72	9.38	8.86
C.D. 0.05	4.3	4.7	4.9	5.2	17.3	21.0	17.4	17.6	2.1	2.8	3.0	3.1	0.4	0.3	0.3	0.3	0.85	0.83	0.91	0.81

Table 2. Genetic variability parameters of different quantitative traits of indigenous *arboreum* cotton of NE region (Pooled analysis 2001-02 to 2003-04)

Characters	GCV (%)	PCV (%)	Heritability (%)	GA (%)
Days to flower	8.94	9.86	82.00	16.71
Plant height (cm)	26.27	27.31	92.48	52.03
No. of balls/plant	54.78	57.45	90.93	107.62
Ball weight (g)	26.98	27.66	94.94	54.10
Seed cotton Yield (Kg/ha)	39.45	40.56	94.59	79.04

cotton yield and boll number was also reported by Duhoon (1989).

The germplasm exhibited significant variation for all the traits along with high estimates of genetic variability and its related parameters. Hence these germplasm could be considered as valuable source of genetic variability for future breeding purposes. Moreover, with the recent trends in globalization of market economy the breeders have to take utmost care for systematic collection, evaluation and maintenance of the indigenous germplasm for the benefit of the farmers and the country as a whole.

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A WEB ENABLED NETWORKING OF NATIONAL SEED PROJECT (CROPS)

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Information has long been recognized as an essential tool to the success of any programme. It is of common knowledge that information is power, and whosoever has the right to information is able to take informed decisions. The wide spread of internet technologies has brought in very important developments in all important sectors of life. It is playing a pivotal role world wide in transfer of information in the sphere of agricultural technology for overall development of this sector and for the people directly or indirectly involved in this sector. Since the National Seed Project is involved in research, seed production and extension of seed technology to remote areas, it needs a system which can be accessed by its contributing centers for exchange of data and results. Simultaneously the system should provide technological know how to the end users i.e., farmers, public and private seed industries interested in Seed Technological Research and Breeder Seed Production. The networking of the project can fulfill the above requirements and can be upgraded as per the need. With these objectives of information transfer to researchers, extension personnel, farmers and seed industry persons without any need of physical contact, a web based information system for National Seed Project (NSP) has been designed and developed.

NSPNET is a web-based application based on three-tier client-sever architecture and can be accessed from any computer connected to the internet and having internet explorer as the browser. It functions at three layers-Client Side Interface Layer (CSIL), Server Side Application Layer (SSAL) and Database Layer (DBL) (Fig. 1).

The Client Side Interface Layer has been implemented using HTML and Vb Script. Server Side Application Layer has been implemented using Active Server Pages (ASP). When the page is requested, the static mark up code and the dynamic content produced by the ASP elements in Server Side Application Layer are combined to form the complete response to the request. Database layer has been implemented using Microsoft Access 2000.

To maintain the system security, three user levels *viz.*, the Super User, the Database Administrator (DBA) and the End User have been created. The end user can see the reports but can't enter/modify the data. The administrator has all the rights to update the present contents of the database or delete irrelevant information from the database. The super user is a person authenticated from each center to enter and update the information for his center after filling in the login form present at the home page.

NSPNET has been designed and developed during March 2002-March 2004. The user interface of NSPNET is menu driven and user friendly. It has home page with menus for accomplishing the tasks of static information retrieval, online data entry/updation, reports generation and getting

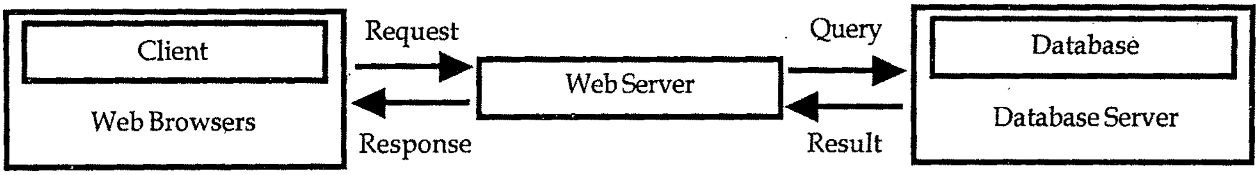

Fig. 1. Three-tier architecture of NSPNET

help. The data entry and updation on various aspects can be done by the authenticated users in the online forms. NSPNET provides the static and the dynamic information about the working of NSP. The static information is available in the form of HTML pages under the menus- About NSP and Help.

The dynamic information is provided in the form of well structured tabular reports generated from the date available in the database the Reports menu. The reports have been categorized as per the function of BSP, STR, General and Seed Availability.

- *BSP reports* provides center wise and crop wise breeder seed production made by various BSP centers against the GOI and State indents.
- *STR reports* provide the detailed information on experiments conducted during a year by STR centers.
- *General reports* provides the information on other different aspects of NSP, like details of publications, staff profile etc.
- *Seed Availability report* provides the facility of generating a report which find out the stock availability of a particular variety of crop seed at NSP centers and displays a consolidated report enlisting the centers in which a specific seed variety is available showing the quantity available in the stock

NSPNET provides all relevant information about the organization and working of NSP to its worldwide users. Creation of centralized database, facilitates an efficient data storage than was previously possible. Also with the web based property, the information dissemination has become easier and broader. The users have advantage to interact with the system from any where in the world with a computer having a web connection.

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INFLUENCE OF ORGANIC AND INORGANIC SOURCES OF NUTRIENTS ON FORAGE PRODUCTIVITY AND ECONOMICS OF OAT (*AVENA SATIVA* L.)

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ABSTRACT

A field experiement was conducted at Indian Grassland and Fodder Research Institute during Rabi seasons of 1996-97 to 1998-99 to access the productivity and economics of forage oat with the combined use of organic and inorganic sources of nutrients. The treatments comprised of vermicompost 10 t/ha, FYM 10 t/ha, 100% recommended dose of NPK (80:40:0), vermicompost 5 /ha, FYM 5 t/ha, 50% recommended dose of NPK + vermicompost 5 t/ha, 50% recommended dose of NPK + FYM 5 t/ha, 50% recommended dose of NPK (40:20:0) + vermicrompost 5 t/ha + FYM 5 t/ha gave significantly higher green fodder, dry matter and crude protein yields of oat than the other treatments. The forage yield exhibited superiority with the treatments where growth parameters attained maximum values. However, the results of forage and crude protein yield were comparable with 100% recommended dose of NPK. Highest net return (Rs. 11575/ha) and benefit: cost ratio (2.60) was obtained with 100% recommended dose of NPK and was significantly higher than best treatment with regard to forage and crude protein yields i.e. 50% recommended dose of NPK + vermincompost 5 t/ha + FYM 5 t/ha (1.14).

Key words : Organic, inorganic, nutrients, forage productivity, economics, oat.

The supply of green fodder to livestock is met through few cultivated forages, sugarcane tops and seasonal weeds in different agro-ecological zones of the country during winter season. Among cultivated forages in rabi, oat is next to berseem in terms of area and production in its growing zones except in western and arid part of the country. It provides palatable and nutritious fodder during the period of acute shortage from mid January to March end and partly supplements the forage supply in addition to berseem. Being a cereal crop, it requires substantial amount of nutrients for higher biomass production. The continuous use of inorganic fertilizers has resulted in ecological degradation, decline in crop productivity and depletion of soil fertility in cereal - based cropping systems prevalent in the country. In this changing scenario, strategic change in nutrient management through integrated input supply systems has shown promise with combined application of different sources of plant nutrients (organic and inorganic) for sustainable crop production without degrading the natural resource base-the soil and that too, on long term basis (Lal and Srivastva, 1995). However, the basic information on organic agriculture postulated that the shift from inorganic to organic nutrient should be gradual and sustainable (IFOAM, 1992). Since information on sustainable forage production of oat through use of organic and inorganic nutrients is meager, an experiment was designed to assess the forage productivity and economic viability of oat cultivation with the integration of vermicompost, FYM and inorganic fertilizers.

MATERIALS AND METHODS

The field experiment was conducted at Central Research Farm of Indian Grassland and Fodder Research Institute, Jhansi during the Rabi seasons of 1998-97 to 1998-99. The soil of the experimental field was clay loam with medium pH (7.8). It was low in organic carbon (0.31%), available nitrogen (192 kg/ha), medium in phosphorous (20.5 kg/ha) and low in available potash (246.0 kg/ha). The experiment was laid out in randomized block design with ten treatments, viz; control, vermicompost 10 t/ha, Farmyard manure (FYM) 10 t/ha 100% recommended dose of NPK, 50% recommended dose of NPK, vermicompost 5 t/ha. Oat variety JHO-822 was sown in rows 25 cm apart using 100 kg seed/ha. The recommended dose of fertilizer (100%) for forage oat was 80 kg N + 40kg P2O5/ha + 0 kg K2O/ha. Well decomposed vermicompost and FYM were applied during land preparation and uniformly mixed up in the soil before opening the furrow for sowing the seed. Half dose of nitrogen and full dose of phosphorous were applied as basal according to treatment levels. Remaining half dose of nitrogen was top-dressed after first irrigation. The crop received uniform irrigation as per requirement. The oat crop was single cut and harvested at 50% flowering stage, which conincides with 85-90 days. The data on growth characters viz., plant height, number of leaves/ plant, number of shoots/plant and leaf-stem ratio and yield (green fodder, dry matter and crude protein) were recorded at the time of harvest. Crude protein yield was estimated as per the procedure suggested by Piper (1996). The economics of different treatment was calculated at the prevailing market rates of labour wages, inputs and outputs. The pooled data of three years (1996-97 to 1998-99) on the growth, yield and economics was statistically analysed for interpreting the results. The data on nutrient uptake and changes in soil fertility after the harvest of oat has also been presented.

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RESULTS AND DISCUSSION

Growth and yield attributes

The mean of three years indicated that varying doses of organic, inorganic and their combinations of plant nutrients significantly influenced growth and yield attributes of oat (Table 1). Application of 50% recommended dose of NPK (40 : 20 : 0) + vermicompost and FYM each 5 t/ha recorded significantly higher number of shoots and leaves/plant and taller plants which remained on par with 50% recommended dose of NPK + vermicompost 5 t/ha, 50% recommended dose of NPK + FYM 5 t/ha and 100% recommended dose of NPK (80 : 40 : 0). The shorter plants were recorded under control and 50% cutaiment in th vermicompost and FYM doses. The reduction in the doses of organic or inorganic nutrients exhibited the reduction in number of leaves. Similarly, leaf-stem ratio, a suitable indicator of better quality fodder, was highest with 100% recommended dose of NPK and remained on par to that of 50% recommended dose of NPK + vermicompost 5 t/ha + FYM 5 t/ha, 50% recommended dose of NPK + vermicompost and FYM each 5 t/ha. Growth and yield attributes of forage oat were consistently influenced with nutrient supply where organic and inorganic sources maintained the availability of nitrogen at optimum level at critical growth stages of the crop. The increase in growth parameters of Deenanath grass due to maintaining the optimum level of N through organic and inorganic sources was also reported by Choubey et al. (2002) from Ranchi.

Forage productivity

Application of 50% of recommended dose of NPK + vermicompost 5 t/ha + FYM 5 t/ha gave significantly higher green fodder yield (40.5 t/ha) on pooled mean basis of three years. However, the green fodder yield (37.6 t/ha) was comparable with 100% recommended dose of NPK (Table 2). The green fodder yield of treatments with 50% recommended dose of NPK + vermicrompost and FYM each 5 t/ha was on par with 100 and 50% of recommended dose of NPK. The treatment having vermicompost as an organic source of nutrients were superior over the treatments with FYM with respect to green fodder yield. It is indicative of the fact that the application of inorganic fertilizer nutrients in combination with organic source is beneficial than application of vermicompost or FYM or inorganic sources of nutrients alone. Increment in green fodder yield of oat may be attributed to enhanced availability and gradual release of required nutrients through organic sources. Jayanthi *et al.* (2002) also reported yield advantage in forage oat at Coimbatore with the application of inorganic and organic source of nutrients together.

The dry matter yield also followed the trend of green fodder yield (Table 2). Significantly higher dry matter yield (10.2 t/ha) was recorded with 50% recommended dose of NPK + vermicompost and FYM each 5 t/ha except with 100% recommended dose of NPK which was on par. Application of 50% recommended NPK along with vermicompost or FYM each 5 t/ha recorded almost equal dry matter yield to that to 100% recommended dose of NPK. Similarly, vermicompost 10 t/ha alone produced equal dry matter to that of 50% curtailment of recommended dose of NPK. The yield attributing characters were highest under treatments 50% recommended dose of NPK + vermicompost 5 t/ha + FYM 5 t/ha which might have contributed to the highest dry matter yield. Besides it may also be subscribed to better physico-chemical soil status and proper release f nutrients for growth of the crop. The results are in conformity to those of Baral *et al.* (1997).

Crude protein yield

The crude protein yield was significantly higher with the application of 50% recommended dose of NPK along with vermicrompost and FYM each 5 t/ha (10.4 g/ha) than rest of the treatments (Table 2). The treatment - wise trend for crude protein yield was almost similar to that of herbage yield. However, 100% recommended dose of NPK remained on par with 50% recommended dose of NPK + vermicompost or FYM 5 t/ha. There was remarkable reduction in crude protein yield with reduction in dose either in organic or inorganic nutrient sources. Among nutrient sources, FYM 5 t/ha recorded lowest crude protein yield (5.3 q/ha), though superior by 39.5 prcent over control. Integrated nutrient supply involving inorganic and organic sources like vermicompost might have benefited the forage oat crop in maintaining higher fertility status, favourable microbiai activity and thereby improvement in quality of fodder. Similar results are reported by Shroff and Devasthali (1992).

Economics

Economic parameters of pooled yield revealed that forage oat fertilized with 100% recommended dose of NPK gave significantly higher net return (Rs. 11575/ha) and benefit : cost ratio (2.60) than rest of the treatments (Table 2). The net return with the application of 50% recommended dose of NPK + Vermicopost 5 t/ha = FYM 5 t/ha was significantly lower than that of 100% recommended dose of NPK. This may be due to high input cost involved in growing of the crop particularly of organic manures such as vermicompost and FYM. The treatments with 10 t/ha of vermicompost and FYM recorded less net return as well as benefit : cost ratio. These findings are in agreement to those of Jayanthi *et al.* (2002).

Nutrient uptake

The uptake of N, P and K increased progressively with the increase in rate of application of vermicompost or FYM due to sustained availability of nutrients (Table 3). The significantly higher uptake of 134.0 kg/ha N, 23.3 kg/ha P and 217.5 kg/ha K was recorded with the application of 50% NPK and vermicompost and FYM each @ 5 t/ha, indicating higher assimilation and uptake of nutrients due to combined application of vermicompost, FYM and inorganic fertilizer. The lowest uptake ws recorded in the control followed by 50% reduced doses of organic manures and inorganic fertilizers. However, the uptake of nutrients due to application of 50% NPK + vermicompost and FYM each @ 5 t/ha was at par with 100% recommended dose of NPK. Choubey et al. (2002) also recorded higher uptake of nutrients by deenanath grass with the integration of organic and inorganic nutrient sources.

Soil fertility after harvest of oat

After three years of experimentation, data on soil analysis indicated that integration of organics and inorganic to forage oat showed remarkable variation in organic carbon (%), available N and K in soil as compared to initial level. However, available P did not differ appreciably. Application of 50% NPK with vermicompost and FYM each @ 5 t/ha improved the fertility status of soil considerably having avilable N-221.5 kg/ha, P-21.9 kg/ha and K-257.8 kg/ha and OC-05% (Table 3). The increase in build up of organic carbon, available soil N and K content might have attributed to maximum left over organic carbon, N and K content in to the soil due to application of various treatments. The magnitude of addition of nutrients with the vermicompost and FYM treatment was more as compared to inorganic sources where nutrients were gradually available in the soil. Sharma and Agrawal (2003) have also reported the improvement in orgnaic carbon and available N in fodder sorghum due to addition of vermicompost.

It could be concluded that application of 50% recommended dose of NPK + vermicompost and FYM t/ha each may be adopted for getting the higher sustainable and quality fodder from single cut oat irrigated condition.

Table 1. Growth parameters of forage oat as influenced by different source of organic and inorganic nutrients (Pooled mean of three years)

Treatment	Plant height (cm)	Number of shoots/meter	Number of leaves/plant	L:S ratio
Control	74.5	62.6	4.2	1.21
Vermicompost 10 t/ha	95.3	78.3	6.1	1.85
FYM 10 t/ha	88.7	75.2	5.8	1.70
100% NPK	104.7	82.9	6.2	1.89
50% NPK	90.5	70.8	5.7	1.66
Vermicompost 5 t/ha	82.3	65.3	5.3	1.67
FYM 5 t/ha	80.5	68.2	5.5	1.63
50% NPK + vermicompost 5 /ha	106.7	82.7	6.5	1.80
50% NPK+FYM 5 t/ha	105.0	80.3	6.7	1.83
50% NPK+vermicompost 5 t/ha + FYM 5 t/ha	109.6	86.3	6.9	1.86
C.D. (P=0.05)	8.2	10.8	0.6	0.18

Table 2. Yield and economics of forage oat as influenced by organic and inorganic source of nutrients (Pooled mean of three years)

Treatment	Yield (q/ha)			Cost of cultivation (Rs./ha)	Gross return	Net return (Rs./ha)	Benefit: cost ratio
	Green fodder	Dry matter	Crude protien				
Control	21.7	4.7	3.8	6110	10850	4740	0.78
Vermicompost 10 t/ha	32.8	7.5	7.1	10096	16400	6304	0.62
YM 10 t/ha	31.1	7.0	6.4	8015	15550	7535	0.94
100% NPK	37.6	8.9	8.6	7225	18800	11575	1.60
50% NPK	33.0	7.4	6.6	6530	16650	10120	1.55
Vermicompost 5 t/ha	29.8	6.7	6.1	8270	14900	6630	0.80
FYM 5 t/ha	26.3	5.8	5.3	7375	13150	5775	0.78
50% NPK + vermicompost 5 /ha	35.7	8.8	8.4	9279	17850	8571	0.92
50% NPK+FYM 5 t/ha	35.0	8.6	8.5	7680	17500	9820	1.28
50% NPK+vermicompost 5 t/ha + FYM 5 t/ha	40.6	10.2	10.4	9488	20300	10812	1.14
C.D. (P=0.05)	4.5	1.1	0.6		1582	560	0.04

Price of green fodder of oat @ Rs. 500/t, Cost of FYM - Rs. 200/t and vermicompost - Rs. 400/t.

Table 3. Nutrient uptake by oat and available nutrient status in soil after oat as influenced by organic and inorganic source of nutrients (Pooled mean of three years)

Treatment	Nutrient uptake (kg/ha)			Available nutrient status in soil after oat harvest			
	N	P	K	Organic carbon (%)	Available N (Kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)
Control	54.7	9.2	91.5	0.28	180.8	20.0	238.5
Vermicompost 10 t/ha	94.0	15.8	151.8	0.40	209.5	21.4	250.5
YM 10 t/ha	86.1	15.3	139.7	0.41	208.0	21.0	251.5
100% NPK	114.1	19.7	179.0	0.36	200.0	20.8	245.0
50% NPK	105.0	15.9	148.3	0.34	196.3	20.7	240.7
Vermicompost 5 t/ha	86.7	14.2	139.6	0.35	198.5	20.9	250.0
FYM 5 t/ha	71.4	12.0	119.2	0.48	218.3	21.3	255.7
50% NPK + vermicompost 5 /ha	111.8	18.9	180.9	0.48	218.3	21.3	255.7
50% NPK+FYM 5 t/ha	109.6	19.1	179.2	0.47	217.7	21.78	253.3
50% NPK+vermicompost 5 t/ha + FYM 5 t/ha	134.0	23.3	217.5	0.50	221.5	21.9	257.8
C.D. (P=0.05)	9.2	0.9	10.7				

Initial fertility status - organic carbon - 0.31% and available N, P & K - 192.0, 20.5 and 249.0 kg/ha, respectively.

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GROWTH AND YIELD ENHANCEMENT OF MUNGBEAN (*VIGNA RADIATA* L.) BY SOURCES AND LEVELS OF PHOSPHORUS AND PHOSPHATE SOLUBILIZING MICROBES

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ABSTRACT

A field experiment was conducted to study the effect of different sources and levels of phosphorus, with and without PSM on growth and yield of mungbean (grain and stover). Application of P along with PSM (growth and yield) showed additive effect on these parameters. Under all Phosphorus x PSM treatments the growth and yield were higher with 60 kg P2 O5 ha-1 than with the lower & higher levels of P. The effect of different sources of phosophorus with PSM on mungbean growth and yield was in order of : RP > DCP > SSP with PSM. The highest yield of grain (8.81 q ha-1) and stover yield (8.63 q ha^{-1}) was obtained with inoculation.

Key words : Sources of phosphorus, PSM, growth and yield.

The productivity of mungbean (*Vigna radiata* L.) is very low. There is a wide scope for increasing pulse production through application of required nutrient specially phosphorus and Biofertilizers. Biofertilizers are cheap and eco-friendly and hence an attempt has been made for optimum use of phosphorus with PSM. About 95% of soils need supplementation of phosphorus for high yield. Only about 20-25% of applied phosphatic fertilizers are utilized by crop plants remaining are being fixed or sendered unavilable to crops by forming insoluble complexes with metal ions and clay minerals. This makes phosphate solubilizing microbes important for sustainable agriculture using soil itself as a phosphate source.

MATERIALS AND METHODS

A field experiment was conducted during 1999-2000 at research farm of R.B.S. College, Bichpuri, Agra. The experimental soil was sandy loam in texture, having pH (1:2) 8.3, EC (1:2) 0.14 dSm-1, available N 162.50 kg ha^{-1}, available P 9.80 hg ha^{-1} and available K 144.00 kg ha^{-1}. The treatment consisted of three phosphorus sources, viz. single super phosphate, di-calcium phosphate and rock phosphate, and two levels of PSM (with and without PSM) in main plots and four levels (0.30, 60, and 90 kg P2O5 ha^{-1}) of phosphorus with each source applied to subplots. There were altogether 24 treatment combinations replicated 3 times in split plot design. Mungbean crop as well as phosphorus including fallow field were fertilized with basal due of other nutrients (N & K) according to the recommended package of practices. Plants were harvested at ground levels at 65 days after sowing for recording the grains and stover yields. After determining fresh weight the plant tops were dried in an oven at 60°C for 72 hours and dry weight were recorded.

RESULTS AND DISCUSSION

Growth and yield attributes

Results showed that the SSP was found most suitable for the development of plant height, number of branches, pods/plant, number of grains/pod and test weight followed by dicalcium phosphate and rock phosphate. The above-mentioned parameters higher with single super phosphate may be ascribed to the presence of more percentage of available phosphorus. Plant height and number of branches non-

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Table. 1 Effect of different sources and levels of phosphorus and PSM inoculation on mungbean

Treatments	Plants height (cm)			No. of Branches/Plant			No. of Pods/Plant			No. of Grains/Pod		
Sources of	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean
Phosphorus												
SSP	58.29	60.51	59.65	6.60	6.88	6.74	14.43	14.80	14.62	6.94	7.27	7.10
DCP	58.43	60.14	59.28	6.53	6.81	6.67	14.18	14.48	14.33	6.86	7.19	7.02
RP	58.40	60.11	59.25	6.52	6.82	6.66	14.15	14.46	14.31	6.85	7.18	7.00
C.D. (P=0.005)	NS	NS		NS	NS		NS	NS		NS	NS	
Levels of Phosphorus												
0	62.25	64.10	63.17	7.29	7.61	7.45	16.90	17.89	17.39	7.67	8.02	7.84
30	62.29	62.14	63.21	7.30	7.62	7.46	16.93	17.93	17.43	7.68	8.09	7.85
60	62.40	62.33	7.33	7.64	7.48	17.01	18.03	17.52	7.71	8.06	7.88	
90	62.32	64.18	63.25	7.31	7.63	7.47	16.95	17.95	17.45	7.69	8.04	7.86
C.D. (P=0.005)	0.0807	0.0931		0.0163	0.0163			0.0713		0.0017	0.0196	
Inoculation with PSM												
Uninoculated	58.04	60.25	59.93	6.55	6.83	6.69	14.25	14.58	14.41	6.88	7.21	7.04
Inoculated	66.10	68.09	67.02	8.06	8.42	8.24	19.65	21.32	20.48	8.50	8.87	8.68
C.D. (P=0.005)	0.0661	0.0691		0.0127	0.0135		0.0472	0.0694		0.0130		

*SSP = Single super phosphate, DCP = Di calcium phosphate, RP = Rock phosphate, PSM = Phospate solubilizing microbes.

Table 2. Effect of different sources and levels of phosphorus and PSM inoculation on mungbean

Treatments	Test height (cm)			Grain Yield (q/ha)			Stover Yield (q/ha)		
Sources of Phosphoru	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean
SSP	31.18	32.64	31.91	7.06	7.30	7.18	7.50	7.82	7.66
DCP	30.83	32.29	31.56	6.99	7.22	7.10	7.46	7.78	7.62
RP	30.80	32.26	31.53	6.98	7.21	7.09	7.45	7.77	7.61
C.D. (P=0.005)	NS	NS		NS	NS		NS	NS	
Levels of Phosphorus									
0	34.64	36.09	35.36	7.82	8.09	7.95	7.95	8.28	8.11
30	34.68	36.13	35.40	7.83	8.10	7.96	7.96	8.29	8.12
60	34.79	36.24	35.51	7.85	8.13	7.99	7.97	8.31	8.14
90	34.71	36.16	35.43	7.84	8.11	7.97	7.96	8.30	8.13
C.D. (P=0.005)	0.0845	0.0794		0.0200	0.0211		0.0093	0.0102	
Inoculation with PSM									
Uninoculated	30.94	32.39	31.66	7.01	7.24	7.12	7.47	7.79	7.63
Inoculated	38.47	39.92	39.19	8.66	8.97	8.81	8.45	8.81	8.63
C.D. (P=0.005)	0.0716	0.0802		0.0141	0.0191		0.0089	0.0078	

*SSP = Single super phosphate, DCP = Di calcium phosphate, RP = Rock phosphate, PSM = Phospate solubilizing microbes significantly and number of pods / plant, number of grains/plant and test weight were significantly increased by the application of P from different sources. (Narayanasamy, 1990, Singht et. al. 1994, and Naik *et al.*, 1993).

A significant and regular increase in above-mentioned parameters was recorded with increasing levels of phosphorus upto 60 kg P_2O_5 ha^{-1} (Table 1). Statistically 60 kg P_2O_5 ha^{-1} in both the years in case of test weight was found to be significant effective over control. However, there was decrease in test weight with 90 kg of phosphorus weight be due to of luxurious consumption of this element by the crop. 60 P_2O_5 ha^{-1} doses along with PSM was also found to be most suitable in producing the heavier grains (Table 2). (Arya and Kalra, 1988 and Rao and Moorthy, 1994).

Grain and stover yields

The sources of phosphorus did not have significant effect on the grain and stover yeilds. The maximum grain and stover yields were recorded with SSP may be ascribed to the presence of more percentage of available phosphorus, which ultimately produced heavier grains. (Gaur and Ostwal, 1972, and Singh *et al.* 1994).

All the levels of the phosophorus except 90 kg P_2O_5 kg^{-1}, significantly and increased the grain and stover yields over control. This value was even higher than the value obtained with 90 kg P_2O_5 ha^{-1}. 0.125, 0.523, 0.251 and 0.123, 0.369 and 0.246% increased the grain and stover yields respectively with 30, 60 and 90 kg P_2O_5 ha^{-1} application over unapplied phosphorus. This increase in the grain yield with the application of phosphorus along with PSM may be boldness and more number of pods and seeds. (Arya and Singh, 1994 and Phookan *et al.*, 1994).

The increase in grain and stover yields with PSM inoculation was 23.73 and 13.10% over the uninoculation. It has been established that these are specific groups of soil microorganisms, which make the phosphorus available to plants not only by mineralizing organic phosphorus compounds but also by rendering inorganic phosphorus compounds more available. (Gaur *et al.*, 1980 and Dubey, 1996).

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STUDIES ON THE MODE OF IRON APPLICATION AND GROWTH REGULATORS ON THE PERFORMANCE OF DIRECT SEEDED UPLAND RICE (*ORYZA SATIVA* L.) VARIETIES UNDER RAINFED CONDITION

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Abstract

Field experiment was carried out to judge the mode of iron application and growth regulators on the performance of direct seeded upland rice varieties under rainfed condition at the Research Farm, Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, during rainy seasons of 2001 and 2002. Two varieties (ZHU-XI-26 and NDR-97) and three growth regulators (control, paclobutrazol and cycocel) were combined to give six main plot treatments whereas five subplot treatments were modes of iron application (control-M0), 25kg $FeSO_4$ ha^{-1} as basal (M1), 1.0% foliar spray (10kg $FeSO_4$ ha^{-1}) and 1.5% (15kg $FeSO_4$ ha^{-1}) at 25 and 35 days after sowing (DAS), respectively (M2), 15 kg $FeSO_4$ ha^{-1} based +1.0 10 h^{-1} foliar spray 15DAS (M1) and foliar spray of 0.1% Fe EDTA at 25 and 35 DAS (M4) were laid out in a split plot design with 3 replications. The available marked products of growth regulators paclobutrazol (cultar) and cycocel (lithocin) were applied @ 100ppm each at 20 and 40DAS through foliar spray. The variety ZHU-XI-26 performed better than NDR-97. Growth regulator paclobutrazol increased grain yield significantly over cycocel application. Among the mode of application, 15kg $FeSO_4$ ha^{-1}as based+ 1.0% (10 kg ha^{-1}) foliar spray 35DAS though at par with foliar spray of 0.1% Fe EDTA at 25 and 35 DAS produced higher yield than other modes of application.

Key words : $FeSO_4$, FeEDTA, growth regulator, iron application, rice.

Research efforts during the last decades have been instrumental in diagnosing and prioritizing various biological and technological constraints limiting productivity of upland rice. The two major problems confronting upland rice production are lack of proper nutrition and moisture stress. Under rainfed upland conditions rice crop often suffers from iron deficiency during the seedling stage due to aerobic conditions, which favours the oxidation of Fe^{++} to Fe^{+++} (Brown, 1961). These ferric forms precipitate and get deposited on the root surface as ferric oxide and ferric hydroxides and prevent the entry of soluble ferrous iron into the root system. As a result, the plant suffers from iron deficiency and exhibits chlorosis in young leaves (Reddy and Prasad, 1986). Iron deficiency chlorosis under upland conditions does not necessarily indicatea deficiency of this nutrient in the soil, but it is indicative of the plant inability either to absorb it from the soil or utilize it efficiently (Brown *et al.*, 1991), plant genotypes differ in their ability to take up Fe (Singh *et al.*, 1992), so Fe efficient varieties should be selected for conditions where Fe deficiencies are likely to occur (Tisdale *et al.*, 1997).

To achieve the maximum yield potential, growth regulators have contributed a great deal to the progress of agricultural sciences. Growth retardants like paclobutrazol and cycocel may improve the physiological and morphological characteristics of rainfed upland rice by manipulating root characteristics and flow rate of photosynthates for grain development. These compounds when used in appropriate concentrations in rainfed upland rice varieties influence the plant architecture in a typical fashion (Dicks, 1980) by phenomenon characterized as (a) inhibition of shoot growth (plant height, internode elogation, leaf area) with unchanged number of internodes and leaves with intensified green leaf pigmentation and (b) maintained or slightly promoted root growth (main roots often longer and thicker). Keeping these facts in view the present investigation was carried out to study the effect of modes of iron application and growth regulators on the performance of direct seeded upland rice varieties under rained condition.

MATERIALS AND METHODS

The field experiment was carried out to judge the modes of iron application and growth regulators on the performance of direct seeded upland rice varieties under rain-fed upland condition at Agricultural Research Farm, Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, during rainy seasons of 2001 and 2002. The soil of the experimental site was sandy loam in texture with pH 7.3. It was low in nitrogen and organic carbon and medium in phosphorus and potassium contents. Two varieties (ZHU-XI-26 and NDR-97) and three growth regulators (control, paclobutrazol and cycocel) were combined to give the siz main plot treatments whereas five subplot treatments were mode iron application [Control-(M0), 25 kg $FeSO_4$ ha^{-1} as basal (M1), 1.0% foliar spray (10 kg $FeSO_4$ ha^{-1}) and 1.5% (15 $FeSO_4$ ha^{-1}) at 25 and 35 DAS, respectively (M2), 15 kg $FeSO_4$ ha^{-1} basal plus 1.0% 10 kg ha^{-1} foliar spray 35 DAS (M3) and foliar spray of 0.1% Fe EDTA (Chelafer) at 25 and 35 DAS (M4)] were laid out in a split plot design with three replications. Urea, diammonium phosphate, muriate of potash, zinc sulphate, ferrous sulphate, Fe EDTA (chelafer) and elemental sulphur were used as sources of nutrients. An uniform dose of 80 kg N, 40 kg P_2O_5, 30 Kg K_2O ha^{-1}, 2.875 kg S and 5.25 kg ZA ha^{-1} were applied to all the plots. Nitrogen was applied in two splits, half as based along with full phosphorus, potassium and zinc and the remaining half at 30 DAS. Iron was applied as per treatments. Sulphur @ 2.875 kg was applied through ferrous sulphate to take care of sulphur. Elemental sulphur @ 2.875 kg S ha^{-1} was given to rest of the plots. The available marked products of the growth regulators paclobutrazol (cultar) and cycocel (lithocin) were applied @ 100ppm each at 20 and 40 DAS through foliar application. Crop response to different treatment was measured in terms of various quantitative and qualitative indices. For this purpose, plant height, dry matter accumulation, grains panicle, test weight, panicle weight, grain yield, straw yield and quality parameters like protein and amylase content, alkali spreading value, hulling, milling and head rice recovery (%) were recorded. Uptake (kg ha^{-1}) of N, P, K and Fe by grain (G), straw (S) and that of G + S were also evaluated after the crop harvest.

RESULTS AND DISCUSSION

A. Crop variety

The crop was subjected to variable weather conditions during the two years of investigation. The variety NDR-97 was taller than ZHU-XI-26 but the latter had higher dry weight than the former. Similarly, in case of yield attributes NDR-97 produced significantly longer panicles but the grains of ZHU-XI-26 were heavier than the former. However, the two varieties did not vary with respect to panicle weight and grains per panicle. Though the variety ZHU-XI-26 produced higher grain yield (32.4 ha^{-1}) during 2001 than NDR-97 (29.4q ha^{-1}) but both were at par during 2002 with respect to grain yield. Since ZHU-XI-26 is relatively tolerant variety to iron deficiency and produced higher yield during the first when then wealth conditions were favorable. The growth of ZHU-XI-26 was more adversely affected due to its short duration duration during second year due to occurrence of drought in the initial growth period. On the other hand, NDR-97 remained unaffected in initial growth and regained growth when favourable conditions returned and this was possible mainly due to its relatively longer duration.

Plant genotypes differ in their ability to take Fe (Singh *et al.*, 1992, 2000) hence efficient cultivars should be selected were deficiencies are likely to occur (Tisdale *et al.*, 1997). Among the varieties ZHU-XI-26 removed more nitrogen, phosphorus, potassium and iron through grain than NDR-97. The quality parameters such as hulling, milling and head rice recovery (%) were higher with ZHU-XI-26 while the amylase and alkali values were higher with NDR-97. Both the varieties were statistically at par with respect to protein content.

Table 1. Effect of different treatments on growth attributes, yield attributes and grain and straw yield of rice

Treatments	Plant height (cm)		Dry matter accumulation (g 0.2 m^2)		Panicle length (cm)		Panicle weight (g)		Grains panicle^{-1} (No.)		Test weight (g)		Grain yield (ha^{-1})		Straw yield (ha^{-1})	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Variety																
V1: ZHU-XI-26	69.9	54.1	194.1	146.3	18.61	18.46	1.70	1.56	70.2	66.4	26.81	25.84	32.4	22.2	43.2	26.5
V2: NDR-97	78.0	62.8	181.8	142.8	20.91	20.65'	1.66	1.62	69.9	67.5	23.54	22.64	29.4	21.8	40.0	26.3
SEm±	0.46	0.83	3.64	3.54	0.13	0.12	0.04	0.02	0.57	0.48	0.09	0.17	0.66	0.37	1.88	0.89
C.D. (P=0.05)	1.46	2.62	11.47	NS	0.41	0.38	NS	NS	NS	NS	0.30	0.54	2.07	NS	NS	NS
Growth regulator																
G_0: Water spray	77.5	63.0	177.2	125.2	19.73	19.52	1.56	1.50	68.40	65.0	24.60	22.79	28.1	20.2	42.5	26.9
G_1: Paclobutrazol (100 ppm at 20 & 40 DAS)	67.6	54.9	195.6	158.8	19.77	19.56	1.75	1.61	71.3	67.9	26.13	25.62	33.5	23.7	39.9	25.9
G_2: Cycocel (100 ppm at 20 & 40 DAS)	76.7	57.7	190.9	149.7	19.79	19.59	1.73	1.66	70.5	67.9	24.78	24.31	31.1	22.0	42.4	26.5
SEm+	0.57	1.02	4.46	4.34	0.16	0.16	0.04	0.02	0.69	0.58	0.12	0.21	0.80	0.45	2.30	1.09
C.D. (P=0.05)	1.79	3.21	14.04	13.67	NS	NS	0.14	0.08	2.19	1.84	0.37	0.66	2.53	1.42	NS	NS
Mode of iron application																
M_0: No Fe	70.2	53.4	156.7	118.7	19.17	18.98	1.28	1.33	61.7	60.4	24.97	23/93	26.5	17.2	33.8	20.6
M_1: 1% (100 kg ha^{-1})	72.9	58.1	181.6	147.7	19.64	19.49	1.62	1.55	68.0	63.0	25.03	24.01	30.6	21.3	40.9	26.2
M_2: 1% (10 kg ha^{-1}) and 1.5% (15 kg ha^{-1}) foliar at 25 and 35 DAS respectively	73.4	59.4	184.7	140.2	19.72	19.56	1.75	1.65	70.3	68.2	25.12	24.26	30.5	22.0	42.7	26.8
M_1: 15 kg ha^{-1} basal and 1.0% foliar (10 kg ha^{-1}) at 35 DAS	77.6	61.9	213.8	147.5	20.40	20.14	1.92	1.78	76.3	73.2	25.54	24.88	34.6	25.4	46.6	29.5
M_4: 0.1% Fe-EDTA foliar at 25 and 35 DAS	75.5	59.7	202.7	148.7	19.86	19.63	1.83	1.64	74.0	69.8	25.22	32.2	24.1	44.1	29.0	
SEm+	0.71	1.01	5.45	5.42	0.20	1.60	0.06	0.04	0.88	0.74	0.14	0.19	1.02	0.58	1.87	1.40
C.D. (P=0.05)	2.02	2.88	15.51	15.44	0.56	0.47	0.16	0.11	2.51	2.12	0.40	0.53	2.91	1.64	5.33	3.99

DAS - Day after Sowing

Table 2. Effect of different treatments on quality characters of rice

Treatments	Protein content (%)		Amylase content (%)		Alkali value (%)		Hulling (%)		Milling (%)		Head rice recovery (%)	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Variety												
V_1: ZHU-XI-26	6.77	7.42	27.29	21.18	2.11	2.00	73.5	73.00	65.50	63.81	55.60	53.30
V_2: NDR-97	6.82	7.53	28.91	29.40	6.04	6.00	66.8	66.20	61.10	58.77	47.40	45.40
SEm±	0.04	0.05	0.111	0.17	0.08	0.07	0.20	0.21	0.31	0.31	0.56	0.60
C.D. (P=0.05)	NS	NS	0.350	0.55	0.25	0.63	0.68	0.96	1.75	1.90		
Growth regulator												
G_0: Water spray	6.72	7.32	27.95	28.54	3.90	3.77	69.40	68.60	62.30	60.94	49.40	47.40
G_1: Paclobutrazol 100 ppm at 20 & 40 DAS)	6.86	7.60	28.14	28.89	4.00	4.00	70.30	70.30	62.60	61.47	52.20	50.70
G_2: Cycocel (100 ppm at 20 & 40 DAS)	6.80	7.50	28.20	28.95	4.33	4.23	70.80	69.60	61.45	52.90	49.90	
SEm±	0.049	0.06	0.136	0.214	0.10	0.09	0.25	0.26	0.37	0.38	0.68	0.74
C.D. (P=0.05)	NS	0.19	NS	NS	0.31	0.27	0.78	0.83	NS	NS	2.15	2.32
Mode of iron application												
M_0: No Fe	6.22	7.00	27.93	28.56	3.78	3.78	67.80	67.30	59.90	58.61	48.60	46.60
M_1: 1% (100 kg ha^{-1})	6.59	7.23	23.73	28.39	4.28	4.06	68.30	67.80	61.20	59.82	49.90	47.90
M_2: 1% (10 kg ha^{-1}) and 1.5% (15 kg ha^{-1}) foliar at 25 and 35 DAS respectively	7.01	7.61	28.10	4.00	3.89	70.10	69.60	61.80	60.50	51.90	49.80	
M_3: 15 kg ha^{-1} basal and 1.0% foliar (10 kg ha^{-1}) at 35 DAS	7.14	7.82	28.35	29.10	3.89	3.94	72.40	71.60	65.10	63.75	52.60	50.30
M_4: 0.1% Fe-EDTA foliar at 25 and 35 DAS	7.00	7.71	28.37	29.12	4.44	4.33	72.20	71.40	66.00	63.75	54.90	52.30
SEm±	0.072	0.07	0.283	0.27	0.22	0.20	0.38	0.34	0.44	0.47	0.92	0.93
C.D. (P=0.05)	0.20	0.21	NS	NS	NS	1.07	0.96	1.27	1.34	2.63	2.65	

DAS - Day after Sowing

Table 3. Effect of different treatments on nutrient uptake (kg ha^{-1}) at harvest

Treatments	Nutrient uptake (kg ha^{-1})															
	Nitrogen uptake				Phosphorus uptake				Potassium uptake				Iron uptake			
	Grain		Straw		Grain		Straw		Grain		Straw		Grain		Straw	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Variety																
V_1: ZHU-XI-26	37.0	27.8	34.8	22.2	8.9	6.3	7.4	4.7	12.5	8.6	88.9	56.0	0.26	0.21	1.30	0.98
V_2: NDR-97	33.9	27.8	34.1	23.1	7.6	5.8	6.6	4.4	11.1	8.2	83.7	56.3	0.22	0.16	1.26	1.05
SEm±	0.73	0.51	1.48	0.89	0.17	0.17	0.18	0.36	0.24	4.13	2.09	0.005	0.005	0.058	0.034	
C.D. (P=0.05)	2.31	NS	NS	NS	0.55	NS	NS	NS	1.1	NS	NS	NS	0.02	0.017	NS	NS
Growth regulator																
G_0: Water spray	31.9	25.1	34.3	22.2	7.5	5.5	6.8	4.3	10.3	7.5	85.1	55.6	0.21	0.16	1.29	1.02
G_2: Paclobutrazol 100 ppm at 20 & 40 DAS)	38.8	30.4	32.7	22.3	9.1	6.6	7.4	4.8	12.8	9.1	83.9	56.8	0.28	0.21	1.22	1.00
G_1: Cycocel (100 ppm at 20 & 40 DAS)	35.6	27.9	36.3	23.4	8.3	6.0	6.8	4.6	12.3	8.7	89.8	56.0	0.24	0.18	1.32	1.02
SEm±	0.89	0.62	1.80	1.08	0.21	0.21	0.49	0.21	0.44	0.29	5.06	2.56	0.006	0.007	0.071	0.042
C.D. (P=0.05)	2.83	1.96	NS	NS	0.68	0.65	NS	NS	1.40	0.92	NS	NS	0.02	0.021	NS	NS
Mode of iron application																
M_0: No Fe	27.7	20.4	24.5	15.8	6.5	4.2	5.3	3.2	9.3	6.1	69.8	41.8	0.17	0.12	0.71	0.59
M_1: 1% (100 kg ha^{-1})	34.0	20.4	24.5	15.8	6.5	4.2	5.3	3.2	9.3	6.1	69.8	41.8	0.17	0.12	0.71	0.59
M_2: 1% (10 kg ha^{-1}) and 1.5% (15 kg ha^{-1}) foliar at 25 and 35 DAS respectively	36.0	28.2	35.2	22.9	7.9	5.8	6.5	4.4	11.1	8.0	85.2	55.7	0.26	0.19	1.37	1.07
M_3: 15 kg ha^{-1} basal and 1.0% foliar (10 kg ha^{-1}) at 35 DAS	37.9	33.3	41.9	27.4	10.9	8.2	10.1	6.2	15.3	11.0	104.0	67.4	0.22	0.25	1.83	1.37
M_4: 0.1% Fe-EDTA DAS	1.21	31.2	38.0	25.8	8.5	6.5	7.0	4.9	12.2	9.2	90.8	61.8	0.26	0.21	1.57	1.20
SEm±	3.44	0.79	1.69	1.29	0.41	0.21	0.50	0.29	0.50	0.31	4.25	3.19	0.010	0.006	0.059	0.055
C.D. (P=0.05)	14.5	2.25	4.80	3.68	1.16	0.61	1.42	0.83	1.42	0.88	12.09	9.08	0.03	0.018	0.17	0.157

DAS - Day after Sowing

B. Growth regulator

The growth regulators (paclobutrazol and cycocel applied @ 100ppm each at 20 and 40 DAS reduced the plant height but finally increased the dry matter production. Cycocel application retarded plant growth by blocking the biosynthesis of gibberlins (Halmann, 1990), checked cell division and cell elongation and its use also thereby reduced plant height. The paclobutrazol treated plants showed starch-degrading activity resulting in improved dry matter accumulated starch was utilized for normal growth activity resulting in improved dry matter production (Yim *et al.*, 1997). The growth regulators did not influence the panicle length but increased panicle weight by 7.3^{-1}2.2 and 10.6^{-1}0.9% with paclobutrazol and cycocel, respectively. As these growth retardants (paclobutrazol and cycocel) probably improved resistance against sdrought stress and therey improved the yield attributing characters (Fletcher and Hofstra, 1998). Growth regualator paclobutrazol increased grain yield significantly over cycocel application. The growth regulators increased the number of vascular bundles and size of phloem area which facilated better translocation of metabolites from source to sink and increased percentage of filled spikelets, 1000-grain weight and grain yield (Ray and Choudhuri, 1981). The effect of paclobutrazol and cycocel was not consistent with respect to nitrogen phosphorus, potassium uptake by grain andstraw but had a significant influence on iron uptake by grain during both the years. The paclobutrazol increased iron uptake more than cycocel. The hulling and head rice recovery (%) increased due to application of growth regulators but the milling (%) and protein content in grain was not affected. The alkali value of grains significantly increased due to foliar spray of cycocel.

C. Mode of iron application

The growth attributes viz. plant height and dry matter production (g 0.2m^2) increased due to basal application of FeSO$_4$ @ 15 kg ha^{-1} along with 1.0% (10 kg ha^{-1}) foliar spray 35 DAS. However, it was significantly at per with foliar spray of 0.1% Fe EDTA at 25 and 35 DAS. Pronounced improvement in yield attributes (grains panicle^{-1}, test weight) and panicle characteristics (panicle length, panicle weight) and finally the grain and straw yields were recorded due to basal application of 15 kg FeSO$_4$ ha^{-1} along with 1.0% (10 kg ha^{-1}) foliar spray 35 DAS which was at par with foliar spray 0.1% Fe EDTA at 25 and 35 DAS (M0). Modes of iron application had a marked effect on N, P, K and Fe uptake by grain and straw and the best result was obtained due to basal application of 15 kg FeSO$_4$ ha^{-1} along with 1.0% (10kg ha^{-1}) foliar spray 35 DAS which was at par with foliar spray of 0.1% Fe EDTA at 25 and 35 DAS. In case of quality parameters, the basal application of 15 kg FeSO$_4$ ha^{-1} along with 1.0% (10 kg ha^{-1}) foliar spray 35 DAS recorded the maximum hulling turn out and protein content while the milling and head rice recovery percentage were higher with foliar application of 0.1% Fe EDTA. None of the interaction effect was significant.

The variety ZHU-XI-26 was better than NDR-97 under rainfed upland condition identical to Indo Gangetic Alluival Plains of Eastern Uttar Pradesh having low irom status. Basal application of 15 kg FeSO$_4$ plus 1.0 per cent foliar spray (10.0 kg FeSO$_4$ ha^{-1}) 35 DAS sustained crop productivity. Application of cycocel @ 200 ml ha^{-1}) in two sprays of 100 ppm each at 20 and 40 DAS proved beneficial.

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EVALUATION OF YIELD AND QUALITY ASPECTS OF INDIAN MUSTARD (*BRASSICA JUNCEA* L. CZERNJ & COSSON) UNDER INTEGRATED NUTRIENT MANAGEMENT

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ABSTRACT

Field experiment was carried out during *rabi* seasons of 2001-02 and 2002-03 to evaluate the response of Indian mustard cv. RH-30 to farmyard manure (2.5 and 5 t/ha), inorganic N (0,40,80 kg/ha) in combination biofertilizers (*Azotobactor chroococcum* and *Azospirillum*). Branches, siliquae/plant, seeds/siliquae, 1000-seed weight seed oil content and oil yield of Indian mustard and yield of seed and stover. Increased significantly with the application of farmyard manures (5 t/ha + *Azotobactor chroococcum* + *Azospirillum*) over the control. Application of N showed liner increase of the characters up to 80 kg/ha.

Key words : Integrated nutrient management, Indian mustard, growth, yield, oil content, oil yield.

Fertilizer management is one of the most important agronomic factor that affects the oilseed crops. Farmyard manurers (FYM) improves the soil properties and finally crop yield (Bhatiya and Shukla, 1982). In view of escalating prices of chemical fertilizer, there is strong need of alternative source of N, especially biofertilizers, in order to supplement the nutrient supply through chemical fertilizers are cheaper, pollution free and renewal (Chauhan *et al.*, 1996). Non-symbiotic bacteria like *Azotobactor chroococcum* and *Azospirillum* are potential biofertilizers. These are capable of contributing N to a number of non-legumes by tapping aerial reservoir and thus indicating their use in Indian Mustard also wherein their agronomic significance is less understood. Moreover, activity of biofertilizers may be influenced by supply of nutrients like N to the soil. The present investigation was therefore carried out evaluation of yield and quality aspects of Indian Mustard (*Brassica juncea* L. Czern & Cosson) under intigrated nutrient management.

MATERIALS AND METHODS

The field experiment was conducted at Bharatpur (Rajasthan) during the winter season at 2001-02 and 2002-03. The experiment consisting of two treatments of bacterial culture (*Azotobactor chroococum* and *Azospirillum*) two levels of F.Y.M. (2.5 and 5 t/ ha) in main plots and three levels of nitrogen (0, 40 and 80 kg N/ha) in sub plots, was laid out in split plot design with 27 treatments and each replicated thrice. Mustard cv. 'RH 30' was sown in rows, 30 cm apart using 5 kg seed/ha on 26 October 2002 and 20 October 2003. The seeds were inoculated with bacterial culture and dried under shade for half an hour before sowing. The crop was thinned 15 days after sowing (DAS) to maintain a plant-to plant spacing of 10 cm. A basal dose of P_2O_5 @ 30 kg/ha (through single super phosphate) was applied uniformly in the whole field. Half doss of N (through urea) and full dos of FYM were also applied one month before sowing. Remaining half of the N was top dressed after the first irrigation.

RESULTS AND DISCUSSION

Biofertilizers

Seed inoculation with either of the bacterial culture significantly increased yield attributes, viz., number of branches and number of siliquae per plant, number of seed per siliquae and 1,000-seed weight (Table 1). Seed yield per hectare, stover yield harvest index, oil content and oil

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Table 1. Effect of bacterial inoculation, FYM and nitrogen levels on yield attributes of Indian mustard

Treatments	Primary branches/plant		Secondary branches/plant		No. of seeds/ siliquae		No of siliquae/ plant		1000-seed wt.(g)	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
Organic Source										
Control	3.64	3.39	11	10.67	5.68	175	167.7	10.17	9.23	
FYM 2.5t/ha	4.96	4.3	12.4	11.89	5/82	5/84	186	178.7	10.93	10.37
FYM 5t/ha	5.36	4.78	12.9	12.46	5.91	5.93	194	185.7	10.85	10.03
FYM 2.5t/ha + *Azotobacter chroococcum*	5.34	4.79	13.4	12.6	5.92	5.95	191	183.3	11.67	10.77
FYM 5t/ha + *Azotobacter chroococcum*	5.86	5.03	13.8	13.42	5.97	201	191.7	11.03	10.34	
FYM 2.5t/ha + *Azospirillum*	5.374.85	13.5	13.09	5.93	5.95	193	184.7	12.36	11.47	
FYM 5t/ha + *Azospirillum*	6	5.47	13.9	13.51	5.95	5.96	204	194	12.38	11.54
FYM 2.5t/ha + *Azotobacter chroococcum* + Azospirillum	5.74	5.22	13.6	12.74	6.09	6	199	189	12.77	11.81
FYM 5t/ha + *Azotobacter chroococcum* + *Azospirillum*	6.22	5.83	14.2	13.73	6.03	6.05	210	199	12.9	11.85
C.D. at 5%	0.17	0.17	0.43	0.32	0.1	0.11	5.93	7.77	0.43	0.84
Inorganic source (N levels)										
0 kg/ha	4.93	4.58	12.6	12.13	5.58	5.59	177	168.4	10.63	9.84
40 kg/ha	5.37	4.83	13.4	12.78	5.98	5.96	200	191.3	11.93	11.02
80 kg/ha	5.87	5.14	13.6	13.13	6.2	6.22	207	198.1	12.4	11.59
SEm±	0.04	0.04	0.12	0.09	0.02	0.03	1.62	2.02	0.11	0.15
C.D. at 5%	0.13	0.13	0.34	0.25	0.08	0.08	4.58	5.71	0.32	0.42

Y_1, 2001-02; Y_2, 2002-03

Table 2. Effect of bacterial inoculation, FYM and nitrogen levels on yield attributes of Indian mustard

Treatments	Seed yield q/ha		Stover yield q/ha		Harvest index %		Oil content %		Oil yield q/ha	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
Organic Source										
Control	11.64	9.99	38.52	34.82	23.01	22.11	39.71	39.47	469.69	395.73
FYM 2.5t/ha	13.08	11.69	42.24	39.53	23.51	22.69	39.77	40.03	527.37	463.73
FYM 5t/ha	14.55	12.94	46.44	42.55	23.73	23.17	40.00	40.45	573.94	516.11
FYM 2.5t/ha + *Azotobactor chroococcum*	13.59	11.98	42.92	39.65	23.91	23.08	39.57	39.45	535.88	473.6
FYM 5t/ha + *Azotobactor chroococcum*	15.38	13.08	47.38	42.57	24.36	23.39	39.85	39.85	611.78	520.69
FYM 2.5t/ha + *Azospirillum*	13.98	12.44	44.02	41.03	23.96	23.12	40.26	40.15	5599.25	500.29
FYM 5t/ha + *Azospirillum*	15.79	13.41	48.47	43.37	24.42	23.5	40.07	40.03	630.13	535.99
FYM 2.5t/ha + *Azotobactor chroococcum* + Azospirillum	14.46	12.91	44.46	41.77	24.36	23.44	40.04	39.51	630.91	515.46
FYM 5t/ha + *Azotobactor chroococcum* + *Azospirillum*	15.81	14.3	48.62	45.26	24.61	23.9	40.09	40.05	570.39	571.65
C.D. at 5%	0.68	0.57	2.39	2.33	NS	NS	NS	NS	24.02	18.52
Inorganic source (N levels)										
0 kg/ha	10.16	9.16	34.39	32.48	2.78	21.96	39.36	39.39	411.65	371.95
40 kg/ha	15.81	13.94	49.1	45.41	24.31	23.45	39.86	39.76	628.32	556.05
80 kg/ha	16.79	14.47	50.66	46.63	24.87	24.06	40.56	40.51	661.14	569.75
SEm+	0.16	0.14	0.6	0.57	0.28	0.26	0.25	0.24	5.79	4.59
C.D. at 5%	0.45	0.38	1.69	1.63	0.28	0.66	0.72	0.67	16.39	12.99

Y_1, 2001-02; Y_2, 2002-03

Table 3. Interaction effect of bacterial inoculation, FYM and nitrogen levels on seed yield

	Nitrogen kg/ha					
	2001-02			2002-03		
Bacterial inoculation	0	40	80	0	40	80
Control	8.01	12.84	13.98	7.02	10.93	12.02
FYM 2.5t/ha	9.26	14.13	15.84	8.14	12.94	14.21
FYM 5t/ha	10.82	15.8	17.04	9.85	13.83	15.13
FYM 2.5t/ha + *Azotobactor chroococcum*	9.51	15.05	16.23	8.43	13.19	14.33
FYM 5t/ha + *Azotobactor chroococcum*	11.47	16.73	17.93	10.3	14.88	14.05
FYM 2.5t/ha + *Azospirillum*	9.67	15.44	16.83	8.79	13.61	14.93
FYM 5t/ha + *Azospirillum*	11.49	17.8	18.1	10.42	15.68	14.13
FYM 2.5t/ha + *Azotobactor chroococcum* + *Azospirillum*	9.89	16.43	17.04	9.03	14.53	15.18
FYM 5t/ha + *Azotobactor chroococcum* + *Azospirillum*	11.26	18.04	18.13	10.5	16.1	16.29
C.D. at 5%	NS		1.15			

yield (Table 2) during both the years. However, both the bacterial strains remained at par with each other. The increase in seed yield over the control was up to 13.9-17.3% and 15.6-18.6 during 2001-02 and 2002-03, respectively. This favorable effect of bacterial inoculation could be attributed to increase in N supply in inoculated plots due to N-fixation ability of these bacteria.

Farmyard manure

Farmyard manure had a significant effect on the growth and yield components seed and stover yields, and siliquae per plant, seed per siliquae, 1,000 seed weight and harvest index during both years. Pooled data indicated that the FYM 2.5 t/ha (11-14.54%) and 5 t/ha FYM (20-22.79%) recorded more yield during 2001-02 and 2002-03 than no FYM application. Significant improvement in seed yield is due to favorable effect of FYM on the growth and yield attributes in plant (Patel and Shelke, 1998). This improvement in yield and quality with increased supply of FYM may be due to enhanced photosynthesis.

Nitrogen

Application of N significantly increased the seed yield. This increase in yield was 35.74 to 39.48% and 34.29 to 36.70% with 40 and 80 kg N/ha during 2001-02 to 2002-03 over the control. All the yield attributes increased significantly with increasing levels of N up to 80 kg/ha, which ultimately resulted in significant increase in grain yield. Similar observations were also reported by Singh and Singh (1998) and Sharma (1994).

Interaction effects

Interaction between biofertilizers and N levels was found significant during both the years (Table 3), which revealed that the inoculated crop receiving moderate levels of fertilizer N (40 kg/ha) gave similar grain yield as the crop receiving higher doses of N (80 kg/ha) but uninoculated. Thus clearly showed that fertilizer, N requirement of the crop was reduced when it was inoculated with the biofertilizers. These results are in close conformity to those of Wani (1990).

Oil content and oil yield

The seed oil content and oil yield was significantly influenced by different levels of integrated nutrient management treatment (Table 2). Increasing farmyard manure and N levels with niofertilizer increase the oil content positively and hence resulted in increasing trend in oil yield. Higher seed oil content was recorded under farmyard manure (5 t/ha) + *Azotobacter chroococcum* + *Azospirillum*. The wider variation in oil yield was largely due to the differences in seed yield because oil yield is the resulted of seed yield and oil content.

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EFFECT OF PHOSPHORUS AND ZINC FERTILIZATION ON GROWTH AND QUALITY OF CLUSTERBEAN [*CYAMOPSIS TETRAGONOLOBA* (L.) TAUB.]

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ABSTRACT

A field experiment was conducted to study the effect of four levels of phosphorus (0, 20, 40 and 60 kg P_2O_5 ha^{-1}) and five levels of zinc (0, 2.5, 5, 7.5 and 10 kg ha^{-1}). The results showed that application of phosphorus significantly increased plant height, number of branches per plant and dry matter accumulation at harvest, root nodules, and LAI at 45 DAS, chlorophyll content at 30, 45 and 60 DAS and protein and gum content of clusterbean upto 40 kg P_2O_5 ha^{-1} over lower doses. Increasing levels of zinc increased the plant height, number of branches per plant, dry matter accumulation, LAI and protein content upto 7.5 kg zinc ha^{-1} and dry weight of root nodules, gum content and chlorophyll content at 45 and 60 DAS upto 5 kg zinc ha^{-1}, while chlorophyll content at 30 DAS of clusterbean increased upto 2.5 kg zinc ha^{-1}.

Key words : Phosphorus, zinc, clusterbean, growth, quality.

Clusterbean [*Cyamopsis tetrogonoloba* (L.) Taub.] is an important rainy season drought resistant grain legume grown extensively on dry lands of India. It can be raised for nutritious fodder, green, manuring, pods for vegetable and seed purposes. Besides, being an industrial crop because ot its high gum and protein content, it also adds to the soil fertility by fixing atmospheric nitrogen and by the addition of organic matter. The average yield of this crop is very low in India (418.49 kg ha^{-1}) and in Rajasthan (874.35 kg ha^{-1}) as well. Poor and imbalance nutrient management is one of the important factor for low yield of this crop (Sundara Rao, 1973). Application of phosphorus especially in legumes favour nodulation, early root growth, plant growth and yield. It also improves the crop quality and resistance against plant diseases.

Zinc is in integral component of a large number of enzymes which regulate the important metabolic reactions in the plant system and also helps in regulating the absorption of water and number of nutrients by the root systems. Proper management of macro and micronutrients in clusterbean can be quite beneficial for enhancing the productivity in arid and semi arid region of India.

MATERIALS AND METHODS

The experiment was conducted at College of Agriculture, Bikaner during kharif, 2001. The soil of the experimental site was loamy sand in texture and low in organic matter, The soil pH was 8.2. It was low in organic carbon (0.09%), available nitrogen (62.85 kg ha^{-1}) and available phosphorus (12.02 kg ha^{-1}) and medium in potassium (129.70 kg ha^{-1}).

The treatments comprised four levels of phosphorus (0, 20, 40 and 60 kg P_2O_5 ha^{-1}) and five levels of zinc (0, 2.5, 7.5 and 10.0 kg Zn ha^{-1}) were laid out in factorial RBD with three replications. Phosphorus was applied through DAP and zinc through $ZnSO_4$. $7H_2O$ as per treatment. After adjusting the nitrogen applied through DAP in different plots, a uniform dose of 25 kg nitrogen ha^{-1} was applied as basal dose through urea. Urea and DAP were drilled in furrows at the time of sowing by "Pora" method while zinc sulphate put after mixing with dry soil, in the open furrows. The clusterbean variety RGC-936 was sown in rows spaced at 30 cm apart at a depth of 5 cm on July 15, 2001 by "Kera" method in open furrows using 20 kg seed ha^{-1}.

RESULTS AND DISCUSSION

Effect of phosphorus

Application of graded levels of phosphorus significantly increased the plant height, number of branches per plant and dry matter accumulation at harvest, dry weight of root nodules per plant at 45 DAS and leaf area index at 45 DAS of clusterbean up to 40 kg P_2O_5 ha^{-1} over lower doses. Further, increase in phosphorus level had no significant effect on all the growth parameters of clusterbean (Table 1). Significant increase in growth parameters of clusterbean may be ascribed to the better nutritional availablity in root zone for growth and development of the crop with the application of phosphorus. The results obtained in this investigation are in close conformity with Reager *et al.*, (2003) in clusterbean.

Increasing levels of applied phosphorus up to 40 kg ha^{-1} significantly increased the protein content, gum content in seed and chlorophyll content at 30, 45 and 60 DAS in clusterbean over lower doses. Further, increase in physphorus level of clusterbean (Table 2). Phosphorus being an energy source also plays an important role in protein synthesis. Gum content was increased due to fat and carbohydrate synthesis in seeds by the increasing levels of phosphorus which enhanced the biosynthesis of phospholipids and nucleic acids. Similar results was separated by Shivran et al. (1996) in clusterbean.

Effect of zinc

dry weight of root nodules per plant at 45 DAS increased significantly with increasing levels of zinc upto 5 kg ha^{-1}, while plant height, number of branches per plant and dry matter accumulation at harvest and leaf area index at 45 DAS of clusterbean increased upto 7.5 kg zinc ha^{-1} (Table 1). Availability of zinc might have stimulated the metabolic and enzymic activity thereby increasing the plant growth parameters. Similar findings have also been reported by Kasturikrishna and Ahlawat (2000). Increasing levels of applied zinc increased the total chlorophyll content at 30 DAS upto 2.5 kg ha^{-1}, while chlorophyll content at 45 and 60 DAS and gum content upto 5 kg zinc ha^{-1} and protein content in clusterbean increased significantly upto 7.5 kg zinc ha^{-1} and after than no significant change was observed (Table 2). Positive effect of zinc application on N content may be due to activation of physiological processes because zinc acts as a catalyst under higher absorption of N by the plant. Similar findings were also reported by Tripathi *et al.* (1997) in chickpea.

Table 1. Effect of phosphorus and zinc on growth attributes of clusterbean

Treatment	Plant height (cm) at harvest	No. of branches per plant at harvest	Dry matter accumulation (g/plant)	Dry weight of rootnudulesat 45 DAS (mg/plant)	LAI at 45 DAS
Phosphorus (kg P_2O_5 ha^{-1})					
0	84.37	10.72	9.37	34.44	1.79
20	97.59	12.21	11.09	39.67	1.97
40	109.26	13.53	12.74	42.37	2.09
60	112.45	13.66	12.92	42.93	2.15
S.Em$\pm$	2.60	0.24	0.27	0.78	0.03
C.D. (P = 0.05)	7.44	0.69	0.77	2.23	0.08
Zinc (kg Zn ha^{-1})					
0	82.53	10.99	9.34	34.54	1.72
2.5	93.40	11.80	10.68	39.19	1.92
5.0	103.65	12.60	11.94	41.74	2.05
7.5	112.83	13.39	12.86	41.86	2.15
10.0	112.19	13.87	12.83	41.91	2.16
S.Em$\pm$	2.90	0.27	0.30	0.87	0.03
C.D. (P = 0.05)	8.30	0.78	0.86	2.49	0.10

Table 2. Effect of phosphorus and zinc on quality parameters of clusterbean

Treatment	Protein content in seed (%)	Gum content in seed (%)	Chlorophyll content (mg/g) fresh weight of levels 30 DAS	45 DAS	60 DAS
Phosphorus (kg P_2O_5 ha^{-1})					
0	22.00	25.74	3.04	2.02	1.62
20	24.81	29.02	3.41	2.19	1.74
40	26.27	30.85	3.67	2.33	1.85
60	27.06	31.67	3.76	2.38	1.87
S.Em+	0.40	0.55	0.08	0.046	0.04
C.D. (P = 0.05)	1.14	1.57	0.24	0.13	0.10
Zinc (kg Zn ha^{-1})					
0	21.81	25.52	3.02	1.98	1.53
2.5	24.00	28.08	3.32	2.13	1.70
5.0	25.68	30.04	3.55	2.28	1.82
7.5	27.00	31.59	3.72	2.37	1.89
10.0	26.81	31.37	3.74	2.39	1.91
S.Em+	0.45	0.62	0.09	0.05	0.04
C.D. (P = 0.05)	1.29	1.77	0.27	0.15	0.11

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YIELD COMPONENTS OF MOTHBEAN (*VIGNA ACONITIFOLIA* (JACQ.) MARECHAL) AS INFLUENCED BY PHOSPHORUS AND BIO-FERTILIZERS

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Abstract

A field experiment was conducted to the study the effect of four levels of phosphorus and four bio-fertilizers. The results showed that application of phosphorus significantly improved the yield attributes viz., number of branches per plant, number of pods per plant, pod length, number of seeds per pod and 1000-grain weight, yield (seed, straw and biological yield), harvest index and benefit: cost ratio of mothbean upto 40 kg P_2O_5 ha^{-1} over control and lower doses. Dual inoculation with Rhizobium + phosphate solubilizing bacteria improved the yield attributes, yield and benefit: cost ratio over single inoculation either with *Rhizobium* or PSB and control. Single inoculation with *Rhizobium* remains statistically at par with inoculation with PSB, increased the all yield attributes, harvest index and benefit: cost ratio of mothbean over control.

Key words : Yield attributes, yield, mothbean, phosphorus, bio-fertilizer, *Rhizobium*, PSB.

Mothbean (*Vigna aconitifolia* (Jacq.) Marechal] is an important rainy season drought resistant grain legume grown extensively on dry lands of India, particularly in Rajasthan. It can be raised for nutritious fodder, green manuring, pods for vegetable and seed purposes. Besides, being pulse, it a cheap source of vegetable protein for balancing nutritional deficiency mostly common on less productive soil on which financially less equipped people having been depending for their livelihood. It also adds to the soil fertility by fixing atmospheric nitrogen and by the addition of organic matter.

Rajasthan is the major mothbean growing state of India, which produces 3.09 lakh tonnes from an area of 13.04 lakh hectares of land (Anonymous, 2002). Phosphorus is a constituent of nucleic acid, phytins and phospholipids. An adequate supply of phosphorus early in plant life is important in laying down the primordial for reproductive parts. It is also an essential constituent of majority of enzymes which are great in transformation of energy in carbohydrate metabolism, fat metabolism and also in respiration in plants (Giaguinta and Quebedeaux, 1980), Phosphorus stimulates nodulation, early root development, plant growth, yield and quality of grain, which improves the crop quality and resistance against plant diseases.

Bio-fertilizers as cost effective eco-friendly and renewable source of plant nutrients to supplement chemical fertilizers in sustainable agriculture system. Bio-fertilizers are the boon for farmers and a need of time because aid in increasing soil fertility. Dual inoculation (*Rhizobium* + PSB) played a vital role in improving three major aspects of yield determination i.e. formation of vegetative structure for higher photosynthesis, strong sink strength through development of reproductive structure and production of assimilates to fill economically important sink (Shrivastava and Ahlawat, 1993).

MATERIALS AND METHODS

The experiment was conducted at College of Agriculture, Bikaner during Kharif 2003. The soil of the experimental field was loamy sand and low organic matter. The soil pH was 8.2. It was low in organic carbon (0.09%), available nitrogen (62.85 kg ha^{-1}) and available phosphorus (12.02 kg ha^{-1}) and medium in potassium (129.70 kg ha^{-1}).

The treatment comprised four levels of phosphorus (0, 20, 40 and 60 kg P2O5 ha^{-1}) and four levels of bio-fertilizers (control, *Rhizobium*,

Table 1. Effect of phosphorus and bio-fertilizers on yield attributes of mothbean

Treatments	Pod/plants	Pod length (cm)	Seeds/pod	Test weight (g)	Number of branches/plant[1]
Phosphorus (kg ha^{-1})					
0	25.24	3.67	4.11	28.35	3.77
20	33.30	4.48	4.77	30.09	4.60
40	39.98	4.76	5.34	31.43	5.15
60	40.42	4.79	5.58	31.48	5.28
SEm±	1.308	0.092	0.132	0.427	0.157
C.D. at 5%	3.779	0.265	0.379	1.232	0.454
Bio-fertilizers					
Control	26.40	3.56	4.23	28.33	3.66
Rhizobium	36.24	4.58	4.95	30.30	4.62
PSB	35.70	4.61	4.98	30.64	4.89
Rhizobium + PSB	40.60	4.95	5.64	32.08	5.63
SEm±	1.308	0.092	0.132	0.427	0.157
C.D. at 5%	3.779	0.264	0.379	1.232	0.454

PSB = Phosphate solubilizing bacteria

PSB and Rhizobium + PSB) were laid out in factorial RBD with three replications. A uniform dose of 20 kg N ha^{-1} through urea and phosphorus as per treatments through single super phosphate were applied at the time of sowing by "Pora method". Bio-fertilizers were applied as per treatments through seed treatment by Rhizobium (MT-20 strain), PSB (*Batillus plimixa*) and Rhizobium + PSB. At first seeds were treated with *Rhizobium* and then by PSB with the help of jaggary solution. The mothbean variety RMO - 257 was sown in rows spaced at 30 cm apart through 'Kera' methods on July 2003 using 15 kg seed ha^{-1}.

RESULTS AND DISCUSSION

Effect of Phosphorus

Application of graded doses of phosphorus significantly increased the number of pods per plant, pod length, number of seeds per pod, number of branches per plant and 1000-grain weight of mothbean upto 40 kg P_2O_5 ha^{-1} over lower doses. Further increase in phosphorus level had no significant effect on all the yield attributes of mothbean (Table 1). Increasing levels of applied phosphorus up to 40 kg ha^{-1} significantly improved the seed yield, straw yield, biological yield, harvest index and benefit : cost ratio of mothbean over control as well as lower doses. Further increment in phosphorus levels up to 60 kg ha^{-1} had no significant variations (Table 2). The regulatory function of phosphorus in photosynthesis and carbohydrate metabolism of plant leaves can be considered to one of the major factor limiting the growth, particularly during the reproductive phase. The level of phosphorus supply during this period regulates the starch sucrose ratio in the leaves and the partitioning of the photosynthates between the leaves also and reproductive organs. Patel *et al.*, (2003) have also reported better growth, yield attributes and yield due to increasing levels of phosphorus in mungbean.

Effect of bio-fertilizers

Dual inoculation with *Rhizobium* + phosphate solubilizing bacteria significantly increased the seed, straw and biological yields, harvest index and benefit : cost ratio of mothbean as compared with control and single inoculation either *Rhizobium* or phosphate solubilizing bacteria. Single inoculation with *Rhizobium* (which were statistically non significant with PSB) improve the yield attributes viz., number of pods per plant, pod length, number of seeds per pod, 1000-grain weight and number of branches per plant as compared to control (Table 1).

Dual inoculation with *Rhizobium* + PSB as well as single inoculation with either *Rhizobium* or PSB significantly increased the seed, straw and biological yields, harvest index and benefit : cost ratio of mothbean over control Dual inoculation also gave significantly higher yield over single inoculated seeds either Rhizobium or phosphate solubilizing bacteria (Table 2). *Rhizobium* and phosphate solubilizing bacteria played an active role in improving availability of N and P to plants through biological nitrogen (BNF) and solubulization of insoluble phosphates. The nitrogen fixed by bacterial fertilizers might have been utilized by the plants in synthesis of protein, carbohydrate, starch and its partitioning towards formation of flower and fruits, which seems to have improved yield components and yield of mothbean. Similar findings have also been reported by Biswas *et al.* (2001) in mungbean and Tanwar and Shekhawat (2003) in soybean.

Table 2. Effect of phosphorus and bio-fertilizers on yield, harvest index and B:C radio of mothbean

Treatments	Yield (q ha^{-1})			Harvest index	B:C ratio
	Seed	Straw	Biological		
Phosphorus (kg ha^{-1})					
0	5.31	14.20	19.51	27.22	1.36
20	7.50	16.28	23.78	31.54	1.77
40	9.18	17.78	26.96	34.05	2.04
60	9.36	18.00	27.36	34.21	1.98
SEm±	0.272	0.516	0.859	0.836	0.044
C.D. at 5%	0.786	1.492	2.483	2.414	0.126
Bio-fertilizers					
Control	6.27	14.01	20.28	29.58	1.456
Rhizobium	7.92	16.75	24.67	32.20	1.81
PSB	7.98	16.43	24.41	32.59	1.81
Rhizobium + PSB	9.18	19.07	28.25	32.65	2.08
SEm±	0.272	0.516	0.859	0.836	0.044
C.D. at 5%	0.786	1.492	2.483	2.414	0.126

PSB = Phosphate solubilizing bacteria

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PHYSIOLOGICAL BEHAVIOR AND YIELD OF RICE (*ORYZA SATIVA*) VARIETIES IN PRE-*KHARIF* AND *KHARIF* SEASON AT MID ALTITUDE OF MEGHALAYA

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Abstract

A field experiment was conducted during 2004 to study the performance of pre-kharif and kharif rice in sunken beds under raised and sunken bed systems of cultivation. The treatment consisted of six varieties of rice in pre-*kharif* and five varieties in *kharif* season grown in sunken beds and other crops (maize & vegetables) on the raised beds. The crops were grown organically and the nutritional requirements of the crops were met through the washings of adjacent rabbit farm of the complex. Results revealed that all the rice varieties took longer duration for their maturity and produced higher number of tillers/plant in pre-*kharif* season compared to main kharif season. Significantly higher ripening ratio and grain yield was recorded in IR 64 (64%, 35.5 q/ha) followed by Krishna Hamsha (62.8% 27.3 q/ha) in pre-*kharif* season, whereas it was found maximum in Vivek Dhan 82 (70.3%, 37.18 q/ha) followed by VL Dhan 61 (69.6%, 28.95 q/ha) in *kharif* season. Significantly higher photosynthesis rate (29.5 u mol CO_2 m-2s-1) and stomatal conductance (495.0 m mol m-2s-1) was observed in Vivek Dhan 82 during *kharif* season compared to other varieties. Chlorophyll Index was found significantly higher in Bhalum 1 followed by Vivek Dhan 82 in both the seasons. Highest transpiration rate was noticed in RCPL 1-87-8 followed by Vivek Dhan 82 in *kharif* season. Therefore, IR 64 and Krishna Hamsha in pre-*kharif* season and Vivek Dhan 82 and VL Dhan 61 in *kharif* season. Therefore, IR 64 and Krishna Hamsha in pre-*kharif* season and Vivek Dhan 82 and VL Dhan 61 in *kharif* season were found suitable under mid hills of Meghalaya.

Key words : Pre-*kharif* and *kharif* rice, stomatal conductance, photosynthesis, yield attributes, raised and sunken bed system, NEH region.

Rice (*Oryza Sativa* L.) is the staple food of the northeastern states of India. But the region is still in deficit of about 1 million tons of rice. Presently, more than one crop of rice is grown only in some low altitude (<250 m msl) areas of Assam, Tripura and Manipur. Boro rice cultivation in isolated pockets of East and West Garo Hills districts of Meghalaya was reported by Verma *et al.* (2003). Successful cultivation of pre-*kharif* rice in mid altitude of Meghalaya was also reported by Munda *et al.*, (2004). Sardana and Sasikumar (1991) reported that low lying areas of Tripura are suitable even for three crops of rice in a year. In mid altitude (>950 m msl), monocropping of rice is prevalent because of the cultivation of long duration traditional varieties and field is left fallow for a longer period. Now with the intorduction of short duration high yielding photo insensitive varieties of rice, double cropping of rice can also be done at mid altitudes for increasing rice production of the region. So far double cropping of rice has not been reported any where at this altitude. Double cropping of rice will increase the cropping intensity as well as rice production of the region. Keeping this view in mind a field experiment was started to study the performance of pre-*kharif* and *kharif* rice in sunken bends under raised and sunken bed system of cultivation in mid hills of Meghalaya.

MATERIALS AND METHODS

The field experiment was conducted during pre-*kharif* and *kharif* season, 2004 at the Agronomy Farm, ICAR Research Complex for NEH Region, Umiam (950 m msl), Meghalaya. The treatment consisted of six varieties of rice in pre-*kharif* season (IR 64, RCM 8, IET 17212, Krishna

Hamsha, Vivek Dhan 82 and Bhalum-1) and five varieties in *kharif* season (Vivek Dhan 82, VL Dhan 61, RCPL 1-87-8, Krishna Hamsha and Bhalum-1) and five varieties in *kharif* season (Vivek Dhan 82, VL Dhan 61, RCPL 1-87-8, Krishna Hamsha and Bhalum-1) in same sunken beds and other crops (maize, coriander, carrot, french bean, and tomato in pre-*kharif* and french bean and cucumber in *kharif* season) were grown on the raised beds in randomized block design. Soil of the experimental plot was low in available nitrogen (189.8 kg/ha) and phosphorus (9.02 kg/ha) and high in available potassium (323.4 kg/ha). The pH and organic carbon content of the soil was 5.55 and 2.47%, respectively. Pre-*kharif* rice was sown by chutaki method (dibbling) in furrows in the second fortnight of February and *kharif* rice was transplanted in the first week of August. Crops on raised beds were sown/transplanted in the first week of February and first week of August in pre-*kharif* and *kharif* seasons, respectively. The crop was grown organically and the nutritional requirements of the crops were met through the washings of adjacent rabbit farm of the complex. Provision has also been made for recycling of organic matter for use in the next season crops. No agricultural chemicals were used for nutrient supply and plant protection. The leaf photosynthesis rate (Pn; mol CO_2 m-^{2}s^{-1}), stomatal conductance (SC; m mol m-$_2$s^{-1}), transpiration rate (TR; m mol m-$_2$s^{-1}) and leaf temperature (0C) were measured on fully developed leaf from top at vegetative stage using portable photosynthesis system (Model CIRAS-2, U.K.) and the chlorophyll index was also measured in the same leaves using SPAD Meter. Leaf temperature depression (LTD) was calculated by subtracting the leaf temperature from atmospheric temperature. Ratio between rates of photosynthesis and transpiration (Pn/TR) was used to determine the water use efficiency (WUE) as described by Rosenberg and Kriiger (1993). Crab trap was used for the control of gundhi bug. Pre-*kharif* and *kharif* rice was harvested in the second fortnight of July and second fortnight of November, respectively. Growth parameters, yield components and yields, chlorophyll index, grain filling rate and different parameters related to photosynthesis were recorded during the course of investigation for comparison among the rice varieties. Crop produce were converted in to Rice Equivalent Yield (REY) based on the prevailing market price. Data obtained were analyzed by adopting standard statistical methods.

RESULTS AND DISCUSSION

Growth parameters

Highest plant height was recorded in Vivek Dhan 82 followed by Bhalum-1 in both the seasons compared to other varieties (Table 1). Root length was recorded maximum in IR 64 (24.4 cm) followed by Krishna Hamsha (22.0 cm) and Bhalum 01 (21.2 cm) in pre-*kharif* season whereas, it was maximum in RCPL 1-87-8 (15.91 cm) followed by Vivek Dhan 82 (14.63 cm) in *kharif* season. Highest number of tillers/hill was recorded in RCM 8 (16.9) followed by IR 64 (12.9) and Krishna Hamsha (12.8) during pre-*kharif* season. Significantly higher number of tillers/hill was recorded in RCPL 1-87-8 (9.65) followed by Vivek Dhan 82 and VL Dhan 61 in *kharif* season. Unlike pre-*kharif* season, where significantly higher dry biomass/hill was registered by IR 64 (47.8g), Vivek Dhan 82 (46.9 g), Krishna Hamsha (43.6 g) and RCPL 1-29 (43.6 g) compared to other varieties, in *kharif* season it was found highest in Vivek Dhan 82 (42.1 g) followed by VL Dhan 61 (41.5 g). All the rice varieties took longer duration for their maturity during pre-*kharif* season compared to *kharif* season. Variety RCM-8 (144 days), Vivek Dhan 82 (144 days), and IET 17212 in pre-*kharif* and Vivek Dhan 82 (125 days) and VL Dhan 61 (127 days) in *kharif* season took minimum duration for maturity. However, IR-64 and Krishna Hamsha in pre-*kharif* season and RCPL 1-87-8 in *kharif* season took significantly longer duration for maturity. In general, all the rice varieties showed reduction in growth parameter values in *kharif* season compared to pre-*kharif* season that may be due to shorter vegetative growth period in *kharif* season.

Yield attributes and yield

Perusal of the data (Table 2) revealed that number of grains/panicle was found maximum in Vivek Dhan 82 in both the seasons followed by IR 64 in pre-*kharif* and VL Dhan 61 in *kharif* season. Significantly higher ripening ratio and grain yield was noticed in IR 64 (64%, 35.5 g/ha) followed by Krishna Hamsha (62.8%, 27.3 q/ha) in pre-*kharif* season whereas, it was found maximum in Vivek Dhan 82 (70.3%, 37.18 q/ha) followed by VL Dhan 61 (69.9%, 28.95 q/ha) in *kharif* season. Lowest grain yield was recorded in RC 8 (9.5 q/ha) and Krishna Hamsha (16.8 q/ha) in pre-*kharif* and *kharif* season, respectively. Low yield in RCM 8 and Vivek Dhan 82 in pre-*kharif* season was mainly due to their susceptibility to gundhi bug infestation lead to poor grain filling, whereas poor vegetative growth and yield attributes resulted in low yield of Krishna Hamsha in *kharif* season. Unlike grain yield, 1000 grain weight was found significantly higher in Bhalum 1 (26.7 g) followed by IR 64 (25.4 g) in pre-*kharif* and Vivek Dhan 82 followed by VL Dhan 61 in *kharif* seasons compared to other varieties. IR 64 and Krishna Hamsha in pre-*kharif* and Vivek Dhan 82 and VL Dhan 61 in *kharif* could give good yield because of better yield attributes.

Photosynthesis and associated parameters

Significantly higher photosynthesis rate (29.5 m mol CO2 $m^{-2}s^{-1}$) and stomatal conductance 495.0 m mol $m^{-2}s^{-1}$) was observed in Vivek Dhan 82 during *kharif* season compared to other varieties (Table 3). Whereas, differences among the rice varieties in terms of photosynthesis rate and stomatal conductance during pre-*kharif* season were found insignificant. Wide variation in leaf photosynthesis rate has been reported among the genotypes of rice (Basuchaudhury and Dasgupta, 1987), wheat (Kumar *et al.* 1998), barnyard millet (Kumar *et al.* 2000) and finger millet (Kumar *et al.* 2002). Variation in stomatal conductance among the genotypes of finger millet has also been reported by Kumar *et al.* (2002) in hill environment. Chlorophyll index was found significantly higher in Bhalum 1 followed by 1 Vivek Dhan 82 in both the seasons.

Transpiration and associated parameters

Varitel effect on transpiration rate, leaf temperature and WUE in pre-*kharif* season were found insignificant except LTD which was significant. Whereas, during *kharif* season varietal effect on transpiration rate, leaf temperature and LTD were found significant and WUE was insiginificant. Highest transpiration rate was noticed in RCPL 1-87-8 followed by Vivek Dhan 82 in *kharif* season. Comparatively higher canopy temperature was observed in VL Dhan 61, Vivek Dhan 82 and Bhalum 1. Maximum LTD was recorded in Krishna Hamsha closely followed by Vivek Dhan 82 and IET 17212 in pre-*kharif* season and Vivek Dhan 82 followed by RCPL 1-87-8 in *kharif* season.

Performance of crops on raised beds

Highest vegetable yield was obtained from carrot (258.6 q/ha) followed by pole type french bean (219.1 q/ha) during pre-*kharif* season and pole type french bean (231.2. q/ha) followed by bush type in *kharif* season. Unlike vegetable yield, highest REY was recorded with coriander (821.6 q/ha) followed by carrot (517.0 q/ha) and pole type french bean (219.1 q/ha) in pre-*kharif* season. Whereas, in *kharif* season pole type french bean gave highest REY followed by bush type french bean. Maize (135.7 q/ha) and cucumber (154.4 q/ha) recorded lowest REY in pre-*kharif* and *kharif* seasons, respectively (Table 5).

Present experiemental results bring out the fact that double cropping of rice is possible even at 950 m ASL in Meghalaya. Variety IR 64 and Krishna Hamsha performed better in pre-*kharif* season and Vivek Dhan 82 and VL Dhan 61 in *kharif* season and gave reasonably good yield even under later transplanted condition. Among the crops grown on raised bed, coriander, carrot and pole type french bean in pre-*kharif* season and pole type french bean in *kharif* season was found remunerative. Therefore, this system of cultivation provides opportunity for efficient utilization of available land and farm resources.

Table 1. Growth parameters of pre-kharif and kharif rice under raised and sunken bed system

Variety	Plant height (cm)		Root length (cm)		Tillers/hill (Total)		Biomass /hill (g)		Maturity period (days)	
	Pre-kharif	kharif	Pre-kharif	kharif	Pre-kharif	kharif	Pre-kharif	kharif	Pre-kharif	kharif
IR 64	63.5	-	23.4	-	12.9	-	47.8	-	152	-
RCM 8	59.3	-	20.4	-	16.9	-	27.1	-	144	-
IET 17212	58.7	-	17.9	-	09.8	-	21.2	-	146	-
Krishna Hamsha	55.8	43.06	22.0	12.90	12.8	6.73	42.6	25.10	155	135
Vivek Dhan 82	109.5	82.73	20.8	14.63	9.4	8.25	46.9	42.10	144	125
V.L. Dhan 61	-	65.30	-	13.05	-	7.82	-	41.50	-	127
Bhalum-1	94.7	62.94	21.2	12.60	7.8	6.80	43.6	38.50	150	131
RCPL-1-87-8	-	59.17	-	15.91	-	9.65	-	40.20	-	148
SeEdm+	3.28	0.92	1.53	0.75	1.44	0.47	6.92	5.57	1.34	1.85
C.D. (0.05)	7.31	2.00	3.40	1.63	3.21	1.02	15.43	12.52	3.00	4.03

Table 2. Yield attributes and yield of pre-kharif and kharif rice under raised and sunken bed system

Variety	Grains/panicle		Ripening ratio (%)		1000-grain weight (g)		Grain yield (q/ha)	
	Pre-kharif	kharif	Pre-kharif	kharif	Pre-kharif	kharif	Pre-kharif	kharif
IR 64	181.9	-	64.0	-	25.4	-	35.5	-
RCM 8	120.1	-	43.0	-	21.9	-	09.5	-
IET 17212	162.8	-	47.3	-	21.9	-	17.1	-
Krishna Hamsha	171.6	83.2	62.8	61.1	23.2	23.05	27.3	16.80
Vivek Dhan 82	185.6	131.1	40.6	70.3	23.8	29.82	18.1	37.18
V.L. Dhan 61	-	129.4	-	69.6	-	27.22	-	28.95
Bhalum-1	178.7	114.1	53.6	63.0	26.7	25.26	24.4	21.84
RCPL-1-87-8	-	127.8	-	62.8	-	22.70	-	25.33
SeEdm+	17.62	2.19	4.81	2.71	0.94	0.40	2.44	1.05
C.D. (0.05)	39.26	4.77	10.73	5.90	2.09	0.87	5.44	2.99

Table 3. Photosynthesis and associated parameters of pre-*kharif* and *kharif* rice under raised and sunken bed system

Variety	Photosynthesis rate (u mol CO_2 $m^{-2}s^{-1}$)		Chlorophyll index		Stomatal conductance (m mol $m^{-2}s^{-1}$)	
	Pre-kharif	kharif	Pre-kharif	kharif	Pre-kharif	kharif
IR 64	20.9	-	45.2	-	1654.8	-
RCM 8	25.9	-	48.1	-	1690.6	-
IET 17212	20.2	-	48.5	-	1520.1	-
Krishna Hamsha	24.3	19.6	46.7	42.4	3148.5	344.2
Vivek Dhan 82	23.9	29.5	51.6	49.8	2376.7	495.0
V.L. Dhan 61	-	26.2	-	48.3	-	406.5
Bhalum-1	26.1	24.5	53.1	50.3	2227.7	485.7
RCPL-1-87-8	-	25.6	-	48.6	-	486.7
SeEdm+	2.80	1.16	1.12	0.97	646.88	34.30
C.D. (0.05)	NS	2.53	2.50	2.11	NS	74.74

Table 4. Yield attributes and yield of pre-kharif and kharif rice under raised and sunken bed system

Variety	Transpiration rate (m mol $m^{-2}s^{-1}$)		Leaf temperature (0C)		Leaf temperature depression (^0C)		Water use efficiency (PnTR)	
	Pre-kharif	kharif	Pre-kharif	kharif	Pre-kharif	kharif	Pre-kharif	kharif
IR 64	10.82	-	27.1	-	3.53	-	1.91	-
RCM 8	11.36	-	27.8	-	3.17	-	2.27	-
IET 17212	10.92	-	27.8	-	3.54	-	1.85	-
Krishna Hamsha	11.72	6.91	26.7	3.87	2.60	2.06	2.84	
Vivek Dhan 82	11.22	9.34	26.9	28.6	3.57	3.22	2.12	3.15
V.L. Dhan 61	-	8.53	-	28.9	-	2.42	-	3.08
Bhalum-1	11.47	9.30	27.7	28.7	3.07	2.90	2.27	2.63
RCPL-1-87-8	-	9.38	-	27.9	-	3.17	-	2.79
SeEdm+	0.67	0.40	0.54	0.52	0.19	0.23	0.17	0.21
C.D. (0.05)	NS	1.07	NS	1.12	0.42	0.50	NS	NS

Table 5. Performance of different crop on raised beds during pre-kharif and kharif seasons

Crops	*Pre-kharif* seaons		*Kharif* season	
	Yield (q/ha) REY(q/ha)		REY(q/ha)	Yield (q/ha)
Tomato	163.0	261.0	-	-
French bean (Pole type)	219.1	438.2	231.2	462.4
French bean (Bush type)	102.0	204.0	105.4	210.8
Coriander (Green leaf)	102.7	821.6	-	-
Carrot	258.6	517.0	-	-
Maize (Green cob)	67,875 nos.	135.7	-	-
Cucumber	-	-	98.5	154.4

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ORGANIC FARMING APPROACH FOR SUSTAINING PRODUCTIVITY OF RAINFED GROUNDNUT

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Abstract

A field experiment on fixed site was conducted during the khaif seasons of 1999, 2000 and 2001 to study the response of organic manures on yield attributes of rainfed groundut and soil nutrient status. Application of FYM @ 10 t/ha recorded significantly higher pod yield (2785 kg/ha) and gross return of Rs. 314471 / ha with THE maximum net realization of Rs. 17597 / ha in pooled results followed by application of RDF. FYM applied @ 10 t/ha every year on a same site resulted in significant increase in available N, P_2O_5 and K_2O.

Key words : Organic manure, FYM, RDF, farm waste.

Groundnut (*Arachis hypogaea* L.) occupies first among oilseed crops grown in the country with an area of 8.3 m ha and contributes 7.1 million tones to the oilseed basket (Chaithanya et. al., 2003). Groundnut crop continues to be an unpredictable legume, showing inconsistency in pod and oil yields. Increase in price of chemical fertilizers and cost of cultivation due to labour and other inputs, there is need for a fresh look to exploit the organic farming approaches using the local manurial sources for growing groundnnut without using much of chemical fertilizers and pesticides, which minimize and environmental pollution and it protect long term fertility of soil by maintaining organic matter and providing crop nutrients indirectly by using relatively insoluble nutrient sources and made available to the plants by the action of soil micro-organisms (Chandraskhar Reddy and Riazuddin Ahmed, 1999). As farmers have to grow the crop for years together with reasonable yield under sustainable farming system and the important of groundnut crop, which is pre dominately grwon during kharif season in Saurashtra region of Gujarat, the present experiment planted and executed.

MATERIALS AND METHODS

A field experiment was conducted on fixed site for the three successive years of 1999, 2000 and 2001 to investigate the influence of organic farming on yield and yield attributes of rain fed groundnut and soil nutrient status on medium black soil of Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh (Gujarat). The soil of the experimental polt was medium in available N and P_2O_5 and high in available K_2O with 7.9 pH. The experiment was laid out in randomized block design with 5 treatment viz., T1 - 100% recommended dose of chemical fertilizer (12.5 - 25.0 - 00 NPK kg/ha), T2 - farm waste @ 10 t/ha (groundnut shell), T3 - 50% RDF + T2, T4 - FYM @ 10 t/ha and T5 - animal litter % 5 t/ha and replicated four times. All the organic manures and chemical fertilizers were applied to individual plots in the previously opened furrows at 60 cm row ppacing as per treatments before sowing the croop and incorporated into the soil. The semi-spreading groundnut variety GG-20 was sown as soon as onset of monsoon. Soil samples i.e. before and after the crop harvest in first year and after harvest during sucessive years were collected from each plot from 0-15 cm soil depth and analyzed. Observations on yield and yield attributes were recorded at harvest from each plot and economic were workout on the basis of current market prices of produce and input used.

Table 1. Effect of various treatments on pod and haulm yield of groundnut

Treatment	Pod yield (kg/ha)				Hauim yield (kg/ha)			
	1999	2000	2001	Pooled	1999	2000	2001	Pooled
T_1	1143	2049	2510	1900	1686	2236	3071	2332
T_2	957	1725	2618	1766	1890	2346	2911	2382
T_3	917	1814	2579	1770	1690	2415	3344	2483
T_4	1170	2180	2785	2045	1586	2207	3356	2383
T_5	971	1721	2274	1655	1690	2238	3264	2397
C.D. (P=0.05)	172.2	168.3	256.0	195.9	NS	298.6	NS	
C.V.%	10.8	5.8	6.5	7.2	11.5	5.6	6.1	7.3

Table 2. Influence of different treatments on quality, soil fertility status and economics in groundnut (Pooled over three years)

Treatment	Shelling (%)	Test weight (g)	Oil (%)	Available nutrients (kg/ha)			Cost of cultivation (Rs./ha)			C:B ratio
				N	P_2O_5	K_2O	Gross	cost	Net	
T_1	70.36	53.39	48.79	198.9	52.7	489.8	29442	12032	17410	1.45
T_2	73.05	57.82	49.15	234.9	40.4	523.5	27522	12850	14672	1.14
T_3	72.23	60.02	50.12	220.2	43.1	550.5	27695	13291	14404	1.08
T_4	74.05	59.30	49.84	261.3	797.3	31447	13850	17597	13694	1.11
C.D. (P = 0.05)	NS	NS	0.82	19.3	2.6	46.2	2711			
C.V.%	1.55	4.04	0.84	5.4	3.4	5.3	6.3			

RESULTS AND DISCUSSION

Yield and yield attributes

The mean data on yield and quality parameters indicated that shelling % and test weight were unaffected due to different organic manure treatments (Table 2). However, oil content was maximum (50.12%) when crop received from waste @ 10 t/ha along with 50% RDF (T3), followed by T4 and T5. The three years of experimentation on organic farming (Table-1) revealed that the application of FYM @ 10 t/ha (T4) recorded significantly higher pod yield of 1170, 2180, 2785 and 2045 kg/ha and remained statistically at par with the application of 100% RDF (T1) during 1999, 2000, 2001 and in pooled results, respectively except during 2001 wherein application of farm waste @ 10 t/ha alone (T2) or in conjunction with 50% RDF (T3) were comparable with the application of FYM @ 10 t/ha (T4). Per cent pod yield increased with the application of FYM 10 t/ha over animal litter applied @ 5 t/ha were to the tune of 20.5, 26.7, 22.5 and 23.5% during 1999, 2000, 2001 and in pooled results, accordingly. No significant differences in haulm yield was noted during first two years but in the third year of experimentation application of FYM @ 10 t/ha produced maximum haulm yield (336 kg/ha) followed by application of 100% RDF (T1) and combined application of fam waste @ 10 t/ha alongwith 50% RDF (T3). The low yield with application of farm waste and animal litter during first two years might be attributed to wider C:N ratio and slow effect of these organics. Kambale *et al.*, (2002) and Kumaran and Solaimalai (2000) reported significant increase in the growth and yield of groundnut due to application of FYM.

Soil nutrient status

The data on soil nutrient status after three years of experimentation (Table 2) indicated that overall improvement in soil fertility were observed when crop was fertilized with organic manures. Application of FYM @ 10 t/ha significantly increased the available nitrogen by 31.4, phosphorus by 27.3 and potassium by 62.8 per cent as compared to only application of 100% RDF. The increase in soil nutrients after harvest of crop was due to addition of these nutrients through the application of FYM, farm waste and animal litter. Addition to thise carbon dioxide and organic acid released during the process of decomposition cause to increase the availability of nutrient from native as well as applied organic fertilizers. These might have contributed towards increased available nutrient status of soil with respect to these nutrient. The results are in agreement with those reported by Vijaya Sankar Babu *et al.* (2004).

Economics

Significantly higher gross return of Rs. 31446 / ha was observed due to application of FYM @ 10 t/ha. The same treatment also noted higher values of net realization (Rs. 17597/ha), while C:B ratio was higher (1.45) when crop fertilized with 100% RDF (Table 1). Kambale *et al.* (2002) also reported similar results.

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EXPLOITATION OF GENETIC VARIABILITY FOR QUALITY TRAITS AND AGRONOMIC CHARACTERS IN QUALITY PROTEIN MAIZE (QPM) GERMPLASM (*ZEA MAYS* L.)

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ABSTRACT

The present study was undertaken to identify maize lines having high protein, oil and grain yield at two locations during kharif 2001. Per se performance and genetic behaviour for 14 yield and quality parameters were studied in 169 genotypes. The experiment was laid out in simple lattice design (13x13 structure) with two replications. The analysis of variance revealed significant variability for all the agronomic and quality parameters and thus helped in selection of specific parents for different characters. Among the fourteen characters studied, the genetic advance as per cent of mean along with higher values of heritability, GCV and PVC estimates was maximum for grain yield per plot and protein yield, indicating that, the genetic variance for these two traits are probably due to their high additive gene effects. From 169 genotypes evaluated ten best lines were identified for their good agronomic and quality traits and entry numbers 117, 60 and 69 were found to be highest yielders along with good quality characters, suggesting that, these lines could be utilized in future breeding programme in developing high yielding potential QPM hybirds.

Key words : Quality protein maize, genetic variability, heritability, genetic advance, *Zea mays* L.

Maize (*Zea mays* L.) is one of the most important crops in India and has highest yield potential than all other cereals. Several millions of people in the developing world across the globe consume maize as an important staple food and derive their protein and calories requirement. Quality breeding programme in maize for improvement of protein and oil content coupled with higher grain yield has been recently rejuvenated in India by the introduction of quality protein maize (QPM) and high oil maize (HOM) germplasm from CIMMYT, Mexico. In the present study, newly developed QPM and high oil maize inbreds with hard endospenn (looking like normal maize kernel type) were evaluated to study the extent of variability existing for protein, oil and yield components and to identify suitable parents for their future use in hybrid breeding programme.

METHOD AND MATERIALS

A total of 169, S3-S4 generation QPM lines (125) and high oil maize lines (44) derived from QPM and high oil maize genepools and populations with normal looking endosperm (Hard endosperm) were taken up for studying genetic variability and to identify superior parents for agronomic, quality and grain yield characters. All the parental lines including two checks [viz., Shakti-1 (QPM composite) and Shaktiman-1 (QPM hybrid)] were evaluated in simple lattice design with three replications during kharif 2001 at two locations namely, Agriculture, Rajendranagar, Hyderbad. Each plot consisted 5m long single row spaced 75 cm apart. Inter plant distance with in the row was 20 cm. All the usual recommended package of practices were followed for raising a good healthy crop. Data were recorded on agronomic and maturity parameters [viz., days to 50% tasselling days to 50% silking, days to 50% maturity, plant height (cm), ear height (cm), cm length (cm), ear girth (cm), 100-seed weight (g), number of seeds per ear, number of seeds per row and grain yield per plot (kg)] in addition to quality parameters like oil content (%), protein yield (kg/ha). Protein content was determined by Micro-Kjeldahl's Procedure (Ao.Ac. 1965). In the Kjedahi nitrogen determination the sample is digested in concentrated sulphuric acid. The sulphuric acid acts as a dehydrating and oxidizing agent. Carbon in the sample is oxidized according to $2H_2SO_4 + C = CO_2 + 2SO_2 + 2H_2O$. The nitrogen of the sample is transformed into ammonia. Carbon dioxide, water and sulphur dioxide escape and the ammonia is held back as ammonium ion (NH4+) in the form of ammonium sulphate. Sodium hydroxide is then added to solution, which transforms ammonium ion into ammonia (NH2) which is distilled off, absorbed in a boric acid solution and titrated with standard hydrochloric acid. Oil content was assessed in the grains using Nuclear magnetic Resonance (NMR) spectroscopy. The data were analyzed as per procedure (Panse and Sukhatme, 1961) for the estimation of variances, co-efficient of variances, habitability in broadscence (h_2) and genetic advance as per cent of mean [Burton (1952), Johnson *et al.* (1955)].

RESULTS AND DISSCUSSION

The information on genetic variability for different characters of economic importance is a pre requisite for a plant breeder to work with any crop improvement. In the present investigation significant differences between the test entries were observed for all the agronomic and quality parameters (Table 1). Among the studied traits, highest variability was observed for grain yield followed by ear length, protein yield, 100-seed weight and number of seeds per row which lowest variability was recorded for days to 50% silking (Table 2). In general, the study revealed sufficient variability for all the agronomic and quality parameters and thus helped in selection of specific for differnt characters. These observation were in accordance with the findling of Dubey and Lambert (1969), Pamin (1986), Szundy (1989), Samanci et al (1998), Chandramohan (1999) and Venugopal (2000).

The characters viz., grain yield per plot, protein yield, number of seeds per row, ear length and 100-seed weight exhibited higher values of genotypic and phenotypic co-efficient of variations. The narrow difference between PVC and GCV values for these characters indicate that, the traits are more influenced by genetic factors with minimum influence of environment and also suggest that, the selection based on these characters would facilitate, successful isolation of desirable genotypes. Singh *et al.* (1995). Mani and Bishi (1999) and Venugopal (2000) were earlier reported similar type of observations for grain yield, protein content and other plant characters.

The GVC alone is not sufficient for the determination of amount of heritable variation. Burton (1952) suggested that, GCV together with the heritability estimates would give the best picture of the extent of advance to be expected by selection. In the present study, most of the characters exhibited high heritability values but the highest heritability was observed for day to 50% maturity followed by grain yield per plot, plant height, protein content, protein yield and number of seeds per row, while moderate to high heritability estimates wre observed only for days to 50% tasselling and number of seed row per car. The characters ear length, number of seeds per row, 100-seed weight, protein yield, oil content and grain yield per plot showed high GCV estimates along with high heritability there by pointing to the improvement of these characters through simple per selection and using them in future hybrid breeding programme for the development of heterotic hybrids. These results were in agreement with the observations of Debnath (1987), Satyanarayana and Sai Kumar (1996), Tusuz and Balabanli (1997) and Mani and Bisht (1999).

The heritability estimates indicate only the effectiveness with which selection of genotype can be based on the phenotypic performance but fail to indicate the real progress. Therefore, high heritability need not always accomplished by genetic progress. However, high heritability estimates along with high genetic gain render the selection more effective (Johnson *et al.* 1955). In this study, the genetic advance, as percent of mean along with high heritability estimates was maximum for grain yield per plot, followed by protein yield. This situation indicates that the genetic variances for these two traits are probably owing to their high additive gene effects (Johnson *et al.* 1955) and thus there is better scope for improvement of these traits through direct selection. While the traits, car length, number of seeds per row, 100-seed weight, ear height, oil content, plant height, car girth and protein content showed moderate genetic advance as per cent of mean along with high heritability values indicating that, the improvement of these characters is possible only through careful directional and restricted selection. The other characters viz., days to 50% tasselling, days to 50% silking and number of seed rows per cob recorded low genetic advance coupled with moderate to high heritability estimates and the character days to 50% maturity had recorded low genetic advance coupled with high heritability estimates revealing the predominance of non-additive gene action ad hence improvement of such traits is complicated and it might be Possible through heterosis breeding. Thus the present results confirm the earlier findings of Debnth (1987), Tusuz and Balabanli (1997) and Mani and Bisht (1999).

In brief, it can be concluded that, the traits namely grain yield per plot and protein yield are the most important Parameters to be considered for effective selection of parental lines to develop high yielding quality protein maize (QPM) hybrids, as these two characters exhibited high variability, heritability combined with high genetic advance as per cent of mean. Among 169 QPM and high oil maize genotypes evaluated, ten best lines were identified for their good agronomic and quality parameters (Table 3) and suggested for their use in future breeding programme in developing high yielding potential QPM hybrids.

Table 1. Analysis of variance for 14 characters in maize

S.No.	Characters	M.S.S.	L.S.D.	C.V. (%)
1.	Days to 50% tasellling	36.698**	2.9855	2.4293
2.	Days to 50% silking	37.437**	1.7220	1.2702
3.	Days to 50% maturity	42.348**	2.2755	1.0298
4.	Plant height (cm)	1443.312**	6.0199	1.8297
5.	Ear height (cm)	234.743**	5.5712	5.0283
6.	Ear length (cm)	13.873**	0.7679	4.0283
7.	Ear girth (cm)	5.108**	0.7171	3.6556
8.	No. of seed rows per cob	6.474**	1.4326	5.2340
9.	No. of seed per row	75.221**	1.5625	3.5240
10.	100-Seed weight (g.)	50.456**	1.5911	3.8207
11.	Protein content (%)	3.558**	0.3328	1.4806
12.	Protein yield (kg/ha.)	4347.738**	37.4150	4.0842
13.	Oil content (%)	2.998**	0.3404	3.1235
14.	Grain yield per plot (kg)	0.795**	0.1343	4.1510

**Significant at 1% level of significance.

Table 2. Estimates of genetic variability for 14 characters in maize

S.No.	Characters	Mean	Range		GCV (%)	PCV (%)	Heritability (%)	Genetic advance	Genetic advance as per cent of mean (%)
			Minimum	Maximum					
1.	Days to 50% tasselling	60.25	50.00	70.50	6.37	6.83	86.9	7.60	12.61
2.	Days to 50% silking	68.00	57.00	79.00	6.24	6.38	95.5	8.61	12.66
3.	Days to 50% maturity	109.50	78.50	120.50	4.05	4.18	98.9	9.04	8.25
4.	Plant height (cm)	162.73	106.85	218.60	16.09	16.19	98.7	54.80	33.67
5.	Ear height (cm)	52.07	27.20	76.95	29.00	19.65	93.4	21.20	40.71
6.	Ear length (cm)	10.80	2.78	18.82	27.15	27.46	97.8	5.33	49.35
7.	Ear girth (cm)	9.76	5.28	14.25	15.89	16.31	94.9	3.17	32.47
8.	No. of seed rows per cob	13.91	8.91	18.90	12.44	13.49	85.0	3.27	23.51
9.	No. of seed per row	26.75	10.00	43.50	27.19	27.42	98.3	12.48	46.65
10.	100-Seed weight (g.)	22.51	8.18	36.85	23.67	24.01	97.1	10.12	44.95
11.	Protein content (%)	10.68	7.88	13.50	11.68	11.78	98.4	2.72	25.46
12.	Protein yield (kg/ha.)	497.18	147.42	846.96	32.44	32.71	98.4	299.84	60.30
13.	Oil content (%)	6.25	3.07	9.42	22.09	22.31	98.00	2.48	39.74
14.	Grain yield per plot (kg)	1.80	0.45	3.15	38.89	38.61	98.8	1.29	71.66

Table 3. Superior maize genotypes identified as parents having high protein coupled with high oil and grain yield

S.No.	Entry No.	Grain yield per plot (kg)	Grain yield per hectare (kg/ha)	Protein content (%)	Protein yield (kg/ha)	Oil content (%)
1.	15	2.03	5413.33	13.07	663.21	8.66
2.	42	2.51	6693.31	12.02	756.07	8.15
3.	53	2.46	6559.98	12.02	739.53	7.70
4.	60	2.65	7066.64	11.78	782.27	7.55
5.	67	2.19	5839.98	12.65	662.84	6.54
6.	69	2.63	7013.31	12.30	806.79	8.31
7.	87	2.04	5439.98	11.59	590.97	8.32
8.	104	2.60	6933.31	11.73	762.41	8.20
9.	117	2.84	7573.31	11.29	801.57	8.22
10.	138	2.37	6319.84	11.32	670.89	7.59

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EFFECT OF DIFFERENT HERBICIDES ON GROWTH AND EFFICACY FOR WEED CONTROL IN ONION (*ALLIUM CEPA* L.) SEED CROP

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ABSTRACT

An exerpiment was conducted to study the comparative efficacy of fluchioralin, pendimethalin and oxyflurofen applied alone and along with hand weeding at 45 days after planting (DAP), 3 hand weeding alone given 20, 40 and 60 days after planting (DAP) and unweeded check were carried out. It was concluded that pendimethalin @ 1.0 kg / ha along with a hoeing and weeding at 45 days after planting (DAP) was found most effective and economically viable weed control treatment for onion seed production.

Onion (*Allium cepa* L) is one of the important vegetable crops grown in India. Onion is grown over an area of 0.47 million hectares with a production of 4.75 million tones (Ranpinse et. el. 2001). The average yield per unit area in India is comparatively low i.e. 10.32 t/ha compared to USA (40.08 t/ha) and Spain (37.42 t/ha). In India are ranking first in the seed rate of 10 kg / ha, our country needs about 4700 tones seed annually. As the onion seeds remain viable for a year, it is essential to produce fresh seed every year and use the same for bulb production. The seed yield per unit area of onion is very low and this can be enhanced by chemical weed control practices. Weeds in this crop are a global problem and the losses due to high weed infestations. It is very poor competitor with weeds because of non branching habit, sparse foliate and shallow root system, Yield losses in onion due to weeds have been reported to the extent of 10 to 70% by Phogat *et al.* (1989). *Chenopodium album* L., *Chenopodium murale* L., *Amaranthus virdis* L., *Anagallis avensis* L., *Digera avensis* forsk., *Cyperus rotundus*., *Trianthema portulacastrum*, *Euphorbia hirta* and *Cynodon dactylon* L. were the major dominant weed observed in the crop and could be minimized by the use of herbicides. Hand weeding is a common practice in India, though it is laborius, expensive and time consuming. Chemical weed control method was found to be a cheaper and less efficient. The weed problem in onion seed crop.

MATERIALS AND METHODS

A field experiment was conducted at Horticulture farm, Rajasthan College of Agriculture, Udaipur during the year 2000 to 2001. The soil of the experimental site was clay loam with ph 8.2. The soil had physical composition i.e. bulk density 1.40 g/cm^3, particle density 2.62 g/cm^3 (piper, 1950) and chemical composition i.e. organic carbon 0.72 percent, total nitrogen 0.073 percent, available P2O5 12.11 kg/ha and available K2O 252 kg/ha. There were twenty treatments namely fluchloralin (0.75, 1.0 and 1.25 kg/ha), pendimethalin (0.75, 1.0 and 1.25 kg/ha) ahd Oxyflurofen (0, 10, 0.15 and 0.20 kg/ha) alone and along with one hoeing and weeding at 45 days after planting (DAP), three hoeing and weeding at 20, 40 and 60 days after planting (DAP) and unweeded check. The design of experiment was randomized block design having three replications.

The bulbs of variety "Udaipur 102" having 2.5 to 3.5 cm diameter were transplanted at a distance of 45 x 30 cm on 19th September during 2000 in a plot size of 3.15 m x 2.10 m. All the package of practices except weed control was followed and pendimethalin were applied one day after planting of bulbs. In weeding and hoeing treatment, 1 hand weeding was given at 45 days after planting in all the combination treatments, whereas, 4 hoeing and weeding were given at 20, 40 and 60 days after planting (DAP).

Table. 1 Effect of different weed control treatments on different parameters on onion

	Treatment	Sprouting % of bulb	Plant height (cm)	No. of leaves/ bulb	Length of leaves bulb	No. of spikes/ bulb	No. of umbel/ bulb
1.	Unweeded check	91.27	106.53	14.57	52.60	1.80	1.53
2.	3 Hoeing & Weeding	93.64	105.60	29.80	48.53	5.10	4.07
3.	Fluchloralin @ 0.75 Kg/ha	88.90	98.40	22.93	45.50	3.17	2.80
4.	Fluchlorali @ 0.75 kg/ ha + 1 Hoeing & weeding at 45 DAP	91.27	102.87	23.67	46.17	3.33	3.00
5.	Fluchloralin @ 1.00 Kg/ha	95.21	103.83	26.47	48.17	3.47	3.20
6.	Fluchloralin @ 1.00 Kg/ha + 1 Hoeing & Weeding at 45 DAP	96.82	105.30	27.08	49.60	3.80	3.60
7.	Fluchloralin @ 1.25 Kg/ha	95.24	98.78	24.20	44.17	3.37	2.93
8.	Fluchloralin @ 1.25 Kg/ha + 1 Hoeing & Weeding at 45 DAP	92.07	99.42	25.07	44.90	3.50	3.20
9.	pendimethalin @ 0.75 Kg/ha	92.87	100.80	24.80	43.57	3.40	3.00
10.	Pendimethalin @ 0.75 kg/ha + 1 Hoeing & Weeding at 45 DAP	94.44	101.27	25.60	44.60	3.53	3.27
11.	Pendimethalin @ 1.00 kg/ha	96.03	105.80	29.33	46.83	3.70	3.53
12.	Pendimethalin @ 1.00 kg/ha + 1 Hoeing & Weeding at 45 DAP	98.38	106.23	30.27	48.80	4.97	4.00
13.	Pendimethalin @ 1.25 kg/ha	89.69	99.93	24.53	42.63	3.63	3.40
14.	Pendimethalin @ 1.25 kg/ha + 1 Hoeing & Weeding at 45 DAP	93.65	100.93	25.67	43.63	3.67	3.40
15.	Oxyflurofen @ 1.25 kg/ha	93.62	97.93	26.53	43.13	2.97	2.60
16.	Oxyflurofen @ 0.100 kg/ha 1 Hoeing & Weeding at 45 DAP	94.43	98.30	28.00	43.83	3.60	3.03
17.	Oxyflurofen @ 0.150 kg/ha	90.52	102.53	27.00	46.47	3.40	2.83
18.	Oxyflurofen @ 0.150 kg/ha 1 Hoeing & Weeding at 45 DAP	89.69	102.60	28.00	47.40	3.27	2.87
19.	Oxyflurofen @ 0.200 kg/ha	84.91	96.66	21.93	42.13	2.87	2.63
20.	Oxyflurofen @ 0.200 kg/ha + 1 Hoeing & Weeding at 45 DAP	87.29	97.53	22.80	43.23	3.20	2.64
	SEM +	2.76	3.18	1.10	1.86	0.16	0.13
	C.D. at 5%	7.89	9.08	3.15	5.32	0.46	0.36

Table 2. Effect of different weed control treatments on weed density (plant/m2 40 & 60 DAP), weed biomass (120 DAP) and WEC (%)

Treatment	Weed density (plant/m^2) 40 DAP	Weed density (plant/m^2) 60 DAP	Weed biomass 120 DAP (q/ha)	WEC (%)
1. Unweeded check	107.64	118.52	4.24	0.00
2. 3 Hoeing & Weeding	19.60	10.30	0.14	96.70
3. Fluchloralin @ 0.75 Kg/ha	34.48	38.20	1.83	56.84
4. Fluchlorali @ 0.75 kg/ ha + 1 Hoeing & weeding at 45 DAP	33.18	16.59	1.06	75.00
5. Fluchloralin @ 1.00 Kg/ha	29.90	36.20	1.47	65.33
6. Fluchloralin @ 1.00 Kg/ha + 1 Hoeing & Weeding at 45 DAP	27.29	15.60	0.84	80.19
7. Fluchloralin @ 1.25 Kg/ha	29.28	36.00	1.42	66.51
8. Fluchloralin @ 1.25 Kg/ha + 1 Hoeing & Weeding at 45 DAP	29.52	14.90	0.80	81.13
9. pendimethalin @ 0.75 Kg/ha	33.08	38.40	1.74	59.43
10. Pendimethalin @ 0.75 kg/ha + 1 Hoeing & Weeding at 45 DAP	30.33	15.17	1.01	76.18
11. Pendimethalin @ 1.00 kg/ha	31.16	38.60	1.34	68.40
12. Pendimethalin @ 1.00 kg/ha + 1 Hoeing & Weeding at 45 DAP	28.00	13.22	0.62	85.38
13. Pendimethalin @ 1.25 kg/ha	29.92	35.80	1.26	70.28
14. Pendimethalin @ 1.25 kg/ha + 1 Hoeing & Weeding at 45 DAP	29.14	13.27	0.58	86.32
15. Oxyflurofen @ 1.25 kg/ha	35.88	37.90	1.68	60.38
16. Oxyflurofen @ 0.100 kg/ha 1 Hoeing & Weeding at 45 DAP	33.06	15.57	0.96	77.36
17. Oxyflurofen @ 0.150 kg/ha	31.20	36.20	1.48	65.09
18. Oxyflurofen @ 0.150 kg/ha 1 Hoeing & Weeding at 45 DAP	28.52	15.26	0.62	85.38
19. Oxyflurofen @ 0.200 kg/ha	30.90	35.90	1.42	66.51
20. Oxyflurofen @ 0.200 kg/ha + 1 Hoeing & Weeding at 45 DAP	31.20	15.30	0.58	86.32
SEM +	1.14	1.01	0.08	-
C.D. at 5%	3.25	2.89	0.23	-

DAP = Days After Transplanting

However, no weeding was done in unweeded check (control) plot. The observatons were recorded on five randomly selected plants. Growth characters were recorded from five randomly selected plants and average was computed. Weeds population and their weed biomass were recorded from the randomly selected spots at three places per plot by using a quandrate of 50 cm x 50 cm. Weed control efficiency (WEC) was worked out by using the formula.

Day matter of weeds in control plot - Dry matter of weeds in treated plot

WEC (%) = x 100

Day matter of weeds in treated plot

RESULTS AND DISCUSSION

The maximum sprouting percentage of bulb was recorded in treatment pendimethain @ 1.0 kg/ha+1hoeing and weeding (98.38) and lowest sprouting percentage in oxyflurofen @ 0.20 kg/ ha (84.91). All the treatments were found non significant over the unweeded check. In all the treatments, plant height were found lower than the unweeded check (106.53 cm), due to shading effect and weed crop competition. However, significantly lowest plant heigh were recorded in treatment T3, T7, T8, T13, T16, T19 and T20. It was noted that among the treatment combinations in which 1 hoeing and weeding was given at 45 DAP had slightly better plant height then only herbicide treatments. All the treatments had significantly higher number of leaves in comparison to unweeded check (14.57). Maximum number of leaves per bulb was found in treatment perdimethalin @ 1.0 kg/ha + 1 hoeing and weeding at 45 DAP (30.27) which were at par with 3 hoeing and weeding (29.80). T6 (27.08, T11 (29.33), T16 (28.00). T17 (27.00) and T18 (28.00). The highest length of leaves was found in unweeded check due to weed crop competition. In comparison to unweeded check, small size of leaves was recorded. In comparison to unweeded check, small size of leaves was recorded in 3 hoeing and weeding but it was also not significantly differed. However, rest of the treatments had significantly smaller leaves over the unweeded check excepts T5, T6, T12 and T18. The maximum included 3 hoeing and weeding at 20, 40 and 60 DAP followed by pendimethalin @ 1.0 kg/ha +1 hoeing and wedding and fluchloralin 1.0 kg/ha + 1 hoeing and weeding treatments. The maximum number of weeds (at 40 and 60 DAP) and weed biomass (at 120 DAP) were recorded in unweeded check treatment because weeds were allowed to growth throughout the growing season. 3 hoeing and weeding (at 20, 40 and 60 DAP) recorded the lowest weed density plant/m2 at 40 and 60 DAP and weed biomass at 120 DAP and highest weed control efficiency (WEC %). This might be due to the fact that hoeing and weeding done at 60 DAP did not allow further weed emergence (patel et. al., 1986). Among herbicidal treatment, at 40 DAP, fluchloralin @ 1.0 kg/ha and 1.25 kg/ ha were significantly reduced weed population over fluchloralin @ 0.75 kg/ha. A similar trend was alson found in oxyflurofen doses. Whereas, pendimethalin @ 0.75, 1.0 and 1.25 kg/ha were at par with respect of weed population at 40 DAP. at 60 DAP, all the weed control treatment significantly reduced the weed density over unweeded check. The least weed density was recorded with treatment 3 hoeing and weeding and treatment 3 hoein and weeding and in combination with 1 hoeing that all the 3 herbicides at 3 levels were equally effective in controlling weed population. All the 3 herbicides in combination with 1 hoeing and weeding had significant effect in lowest weed biomass at 120 DAP in comparison to herbicides alone. Similar results were also reported by singh et. al., (1998) was found with treatment 3 hoeing and weeding followed by treatment T14 and T20 respectively.

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EFFECT OF PHOSPHORUS, POTASH AND *RHIZOBIUM* ON POD YIELD, NUTRIENT UPTAKE AND RESIDUAL AVAILABLE SOIL NPK OF VEGETABLE COWPEA

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ABSTRACT

Field experiments were conducted during 2001 and 2002 at research farm of CARI, Port Blair using Arka Garima variety of vegetable cowpea to study the pood yield, nutrient uptake and residual available soil NPK by various levels of phosphorus potash and *Rhizobium* inoculation with and without nitrogen. The results revealed that maximum average yield of green pods was obtained with the application of 80 kg, P, 120 kg K, 20 kg N/na + *Rhizobium* inoculation. The length of root, uptake of phosphorus, available phosphorus, and potash in soil was recorded maximum with the application of 120 kg P, 120 kg K and 20 kg N + Rhizobium inoculation.

Key words : Vegetable cowpea, NPK, *Rhizobium*.

Among legumes, cowpea (*Vigna sinesis* Savi) is one of the most important vegetable grown round the year in Andaman for its tender pods which form a rich source of minerals, vitamins and protein (Choudhury, 1967 and Gopalan *et al.* 1982). In the Islands, cowpea is grown for green pods as vegetable, due to shortage of other vegetables throughout the year. The yield is influenced by several management factors including nutrition (Haldavanekar *et al.* 1992). The soil of Andaman and Nicobar Islands are generally poor in plant nutrients and all crops respond to the application of fertilizers (Singh *et al.* 1988). The phophorus and potash give scope for improving P use efficiency through K application and vice versa (Jamadagni and Birari, 1994). In cowpea nitrogen is fixed in the soil from the atmoshphere by nitrogen fixing bacteria found in the root nodules.

Phosphorus is another of immediate need, since it enhances the nitrogen fixation capability in pulses. The starter does of nitrogen to legumes favors growth and development of plant and yield (Mishra and Solanki, 1996). Phosphorus also increases the residual soil N and P contents (Sinha and Ray, 1991). Heavy and uneven rainfall leads to the leaching of nutrients in these islands. Now-a days there is need for increasing the vegetable production by improving soil fertility and such information is not available for these islands separately. Hence, the proposed study was undertaken to find out the optimum nutrients requirement of cowpea cv. 'Arka Garima' and also to see the available residual NPK content in soil and nutrient uptake studies in Andaman.

MATERIALS AND METHODS

The experiments were conducted at Central Agricultural Research Institute, Port Blair during Rabi season of 2001 and 2002. The soil of experimental plot was clayey loan in texture having good drainage and contained 0.96% organic carbon. The soil was medium in available NPK, which contained 322.82 kg N/ha, 18.44 kg P/ha and 245.14 kg K2O/ha with 5.85 pH value. The experiments were laid out in split-plot design with three replications keeping P and K in main plot and Rhizobium/nitrogen in sub-plot. The treatments included four levels of phosphorus, viz. (0, 40, 80 and 120 kg/ha) three levels of potash i.e. (0, 60 and 120 kg/ha) and Four of *Rhizobium* inoculation with and without nitrogen, which were designated, like N0, N1, N2 and N3, respectively. There were altogether 48 treatments. The crop was sown in the month of December during both the years. The plant distance was maintained as 40 x 20 cm in a plot size of 8.0 x 3.0 m. The fertilizers super phosphate and muriate of potash, respectively; while nitrogen @ 20 kg/ha was given treatment wise through urea along with P and K. The cowpea seed was seed was treated with Rhizobium culture just before half an hour sowing. Regular cultural operations as well as plant protection measures were done according were done according to need of the crop. Observations were recorded on nodulation, nutrient uptake studies of plant parts after 45 days of sowing, pods yield and available soil NPK after crop harvest.

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RESULTS AND DISCUSSION

(i) *Effect of phosphorus*

The different doses of phophorus had affected the length of root, fresh wt. of nodules per plant, dry wt. of nodules per plant and uptake of potash during 2002, but these characters could not show any significant effect during 2001; whereas, yield of green pods, uptake of phosphorus and available soil NPK after crop harvest were found significant during both the years due to application of phosphorus. The uptake of nitrogen was found non significant during both the years (Tables 1 and 2). The maximum longest root per plant was recorded at 120 kg phosphorus/ha, fresh and dry wt. of nodules per plant was found with the application of 40 kg phosphorus per hectare. The maximum yield of green pods during both the years as well as pooled was recorded at 80 kg/ha, but it was at par with 120 kg P/ha. Uptake of phosphorus, was maximum under 120 kg P/ha during both the year over control; while potash uptake through plant part was higher at 40 kg P/ha, but it was statistically on par with 120 kg P/ha and control.

It is obvious from the Table 3 that all the doses of phosphorus viz. 40, 80 and 120 kg/ha had left significantly more N in soil after crop harvest as compared to control (P0) during both the years of experiments; however, 40 and 80 kg P/ha were found on par and there was no statistical difference in between them. All the three doses of phosphorus viz. 40, 80 and 120 kg/ha significantly increased the P content in soil over control during both the years and therefore application of 120 kg/ha recorded significantly the maximum P in soil after crop harvest. The data compiled in Table 3 revealed that K content of soil increased with increase in phosphorus dose upto 80 kg/ha (P2) only. Phosphorus dose of 120 kg/ha showed a declining trend on the K content of soil.

(ii) *Effect of potash*

The application of potash had differed significantly on green pods yield, uptake of phosphorus and available N, K in soil during both the years, however, length of root, fresh and dry wt. of nodules/plant, different significantly only during second year i.e. 2002, while uptake of nitrogen and potash could not show any significant effect due to potash application during both years. The application of 120 kg K_2O/ha had produced maximum length of root per plant, fresh and dry wt. of nodules per plant, yield of green pods in pooled, available P and K in soil; where as yield of green pods was on par with the application of 60 kg K_2O/ha. But uptake of phosphorus and avaialbe N in soil were found maximum with the application of 60 kg K_2O/ha (Tables 2 and 3)

(iii) *Effect of Rhizobium inoculation*

The effect of *Rhizobium* inoculation with and without nitrogen had significantly affected all the characters during 2001 and 2002. The length of main root per plant was found maximum with the application of nitrogen alone @ 20 kg/ha over control during 2001, but it was maximum at 20 kg N/ha with *Rhizobium* inoculation during 2002. In regard to fresh weight of nodules during 2001, the treatment (Ni) i.e. Rhizobium inoculation alone recorded maximum weight, but treatment (N1), *Rhizobium* + 20 kg N/ha was also on par. During 2002, application of nitrogen alone @ 20 kg/ha produced maximum fresh and dry wt. of nodules per plant. The yield of green pods, during both the year was recorded highest at (N3) level i.e. Rhizobium inoculation + 20 kg N/ha.

The nutrients uptake of NPK and available soil NPK were also recorded maximum with the application of *Rhizobium* inoculation + 20 kg N/

Table 1 Effect of phosphorus, potash and Rhizobium inoculation on roots, nnodules and green pods yield of vegetable cowpea, variety Arka Garima

Treatment	Fresh wt of nodule/plant (mg)			Dry wt. of nodules/plant (mg)			Yield of green pods (mg)			Length of root (mg)		
	2001	2002	Average	2001	2002	Average	2001	2002	Average	2001	2002	Average
Level of phosphorus												
0 kg/ha (P_0)	462.138	542.75	502.75	242.416	326.555	284.48	77.15	100.61	88.88	16.01	16.60	16.30
40 kg/ha (P_1)	623.361	969.83	796.59	315.694	531.944	581.66	85.67	113.59	99.63	15.62	15.13	15.37
80 kg/ha (P_2)	391.611	783.05	587.33	227.805	416.333	435.97	96.19	128.36	112.28	14.84	16.22	15.53
120 kg/ha (P_3)	414.00	732.75	573.37	226.00	380.91	303.45	93.28	126.24	109.76	16.06	17.36	16.71
C.D. at 5%	NS	44.947	-	NS	41.710	-	5.46	4.44	-	NS	0.987	-
Level of potash												
0 kg/ha (K_0)	526.562	717.77	622.16	277.000	398.729	476.36	71.42	103.17	87.29	15.47	16.01	15.74
60 kg/ha (K_1)	438.916	718.08	578.49	217.000	377.585	297.29	95.02	124.35	109.69	15.31	15.76	15.53
120 kg/ha (K_2)	452.854	835.43	644.14	264.479	465.500	364.989	97.78	124.09	110.93	16.04	17.22	16.63
C.D. at 5%	NS	38,924	-	NS	36.122	-	4.73	3.84	-	NS	0.854	-
Rhizobium culture												
0 Control (N0)	361.916	386.27	374.09	185.277	209.750	197.51	76.58	93.73	85.16	14.37	13.05	
Rhizobium inoculation (N_1)	560.944	786.80	673.87	288.583	425.166	356.87	84.88	114.98	99.93	15.25	15.72	15.48
Nitrogen at 20 kg/ha (N_2)	444.555	984.38	696.46	239.166	512.166	375.66	91.16	121.73	106.44	17.07	17.08	17.07
Rhizobium + 20 kg N/ha (N_3)	523.69	906.91	715.30	298.888	507.555	403.22	99.67	138.39	119.03	15.74	19.48	17.61
C.D. at 5%	111.990	121.545	-	49.746	38.512	-	2.25	2.78	-	1.33	0.726	-

Table 2. Effect of phosphorus, potash and *Rhizobium* on uptake of NPK through plant parts in vegetable cowpea, variety Arka Garima

Treatment	Uptake of nitrogen (kg/ha)			Uptake of phosphorus (kg/ha)			Uptake of potash (kg/ha)		
	2001	2002	Average	2001	2002	Average	2001	2002	Average
Level of phosphorus									
0 kg/ha (P_0)	22.26	21.65	21.95	3.47	3.84	3.65	12.99	14.71	13.85
40 kg/ha (P_1)	20.86	2.09	20.97	4.40	5.51	6.97	14.36	15.01	14.68
80 kg/ha (P_2)	20.82	21.31	21.06	5.06	4.57	4.81	14.29	13.30	13.79
120 kg/ha (P_3)	20.39	20.88	20.63	5.35	5.38	5.36	14.37	14.86	14.61
C.D. at 5%	NS	NS	-	0.470	0.341	-	NS	1.219	-
Level of potash									
0 kg/ha (K_0)	20.95	20.95	20.95	4.14	4.17	4.15	13.56	14.24	13.90
60 kg/ha (K_1)	21.17	21.14	21.15	5.28	5.37	5.32	14.33	14.77	14.55
120 kg/ha (K_2)	21.13	21.60	21.36	4.29	4.66	4.47	14.09	14.40	14.24
C.D. at 5%	NS	NS	-	0.0806	0.296	-	NS	NS	-
Rhizobium culture									
0 Control (N_0)	18.45	19.49	18.97	3.83	4.47	13.18	13.77	13.47	
Rhizobium inoculation (N_1)	21.13	20.50	20.81	4.31	4.18	4.24	13.75	14.26	14.00
Nitrogen at 20 kg/ha (N_2)	21.18	21.59	21.38	4.70	4.69	14.31	14.45	14.38	
Rhizobium + 20 kg N/ha (N_3)	23.57	23.35	23.46	5.44	5.59	5.51	14.74	15.40	15.07
C.D. at 5%	0.776	0.736	-	0.358	0.411	-	0.924	0.731	-

Table 3. Effect of phosphorus, potash and *Rhizobium* inoculation on available NPK in soil after harvest of vegetable cowpea, variety Arka Garima

Treatment	Available N in soil (kg/ha) after crop harvest			Available P in soil (kg/ha) after crop harvest			Available K in soil (kg/ha) after crop harvest		
	2001	2002	Average	2001	2002	Average	2001	2002	Average
Level of phosphorus									
0 kg/ha (P0)	321.84	321.81	322.82	18.57	18.31	18.44	246.01	244.27	245.14
40 kg/ha (P1)	345.77	339.57	342.67	21.47	21.03	21.25	276.24	277.41	276.82
80 kg/ha (P2)	342.60	340.02	341.31	22.84	22.72	22.78	283.03	280.36	281.69
120 kg/ha (P3)	334.71	330.69	332.70	27.05	26.46	26.75	270.86	274.42	272.64
C.D. at 5%	4.757	5.817	-	0.866	0.551	-	2.241	2.163	-
Level of potash									
0 kg/ha (K0)	332.67	328.49	330.58	22.15	21.83	21.99	253.94	256.88	255.41
60 kg/ha (K1)	342.01	340.16	341.08	22.39	22.00	22.19	269.97	270.05	270.01
120 kg/ha (K2)	335.51	330.42	332.96	22.90	22.56	22.73	283.20	280.04	281.62
C.D. at 5%	4.118	5.037	-	NS	0.477	-	1.941	1.874	-
Rhizobium culture									
0 Control (N0)	328.01	324.64	326.32	20.46	20.06	20.26	259.12	259.46	259.29
Rhizobium inoculation (N1)	329.45	327.58	328.51	21.84	21.67	21.75	269.88	269.14	269.51
Nitrogen at 20 kg/ha (N2)	337.26	333.42	335.34	23.31	22.79	23.05	274.25	271.56	272.90
Rhizobium + 20 kg N/ha (N3)	352.20	246.45	349.32	23.32	24.00	24.16	272.87	276.29	274.58
C.D. at 5%	3.871	3.175	-	0.903	0.662	-	3.347	1.507	-

Table 4. Effect of interaction between level of phosphorus, potash and *Rhizobium*/nitrogen (P x K x N) yield of green pods (q/ha) in (pooled)

Treatment combination	Level of Rhizobium/nitrogen			
	N_0	N_1	N_2	N_3
P_0K_0	60.02	70.63	80.12	92.26
P_0K_1	83.70	92.76	93.31	100.15
P_0K_2	75.78	93.59	106.99	111.28
P_1K_0	65.20	75.53	86.86	97.19
P_1K_1	79.43	91.54	98.81	120.54
P_1K_2	102.04	117.06	126.85	134.55
P_2K_0	81.39	96.68	97.09	118.64
P_2K_1	115.70	124.10	128.48	147.37
P_1K_2	88.58	105.81	117.43	126.12
P_3K_0	74.91	93.78	93.73	106.71
P_3K_1	96.22	121.72	124.48	136.74
P_3K_2	92.93	115.93	123.15	136.85
C.D. at 5%	5.005			

ha during both the years. Only available K during 2002 was found maximum at 20 kg N/ha (N2) but, it was on par treatment (N2).

(iv) Interaction effect of (P x Kx N) on yield of green pods (q/ha) in pooled

Perusal of data given in Table 4 clearly reflects effect of P x K x N interaction on green pods yield in pooled analysis. Application of 80 kg P, 60 kg K and 20 kg N/ha with *Rhizobium* inoculation (P2K1N1) produced significantly maximum yield (147.35 q/ha) whereas P0K0N0 produced only (60.02 kg/ha) yield. However, treatments P1K2N3, P3K1N3 and P3K2N3 were found on par themselves.

By seeing the overall performance of phosphours, potash and *Rhizobium* inoculation with the without nitrogen, it may be concluded that application of 80 kg P, 120 kg K and 20 kg N/ha + Rhizobium inoculation had performed well on various characters in this study. Baboo and Sharma (1995) reported in fenugreek that application of 25 kg N/ha + *Rhizobium* inoculation and 80 kg P/ha recorded higher yield and uptake of N and P. The increased nutrient uptake might be due to greater availability of nutrient through inorganic and biological sources by enhancing the combial activity of root hair root proliferation and cell development in the root surface area. Nimje and Seth (1988) found that nitrogen content of Soyabean plant at flowering was significantly increased up to 40 kg P/ha, while P and K contents were increased upto 80 kg P/ha. Further, they also reported that at harvest, the uptake of N, P and K increased significantly as a result of phosphorus fertilization. Raju *et al.* (1991) observed that increasing levels of P from 20 to 60 kg/ha had significantly increased the N, P and K uptake a chickpea cultivars. In general, available N and P of soil after crop harvest increased considerably as compared to initial level of soil available N and P.

The effect of P levels was more pronounced suggesting that increasing levels of P significantly increase the residual available N and P of soil after crop hargest. Detroja *et al.* (1997) studied the effect of phosphorus and bio-fertilizer on yield, P uptake and P status in soil after crop harvest of Groundnut crop. They reported that phosphorus did not exert their significant effect on pod yield and P uptake, but available P content in soil after crop harvest was significantly increased with each increase in level of P and highest available P_2O_5 in soil was obtained under 50 kg P/ha, followed by 25 kg P/ha and control. Similarly Baldeo Singh *et al.* (1992) reported that *Rhizobium* culture significantly increased the yield, and soil available nitrogen by cowpea in Rajasthan. These findings show close agreement with the present experiments.

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CHARACTER ASSOCIATION AND PATH ANALYSIS IN RICE (*ORYZA SATIVA* L.)

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ABSTRACT

Thirty F_1 hybrids and thirteen parents were studied for estimating the genotypic and phenotypic correlation coefficients and path effects of yield attributing traits on grain plant^{-1}. Grain yield plant^{-1} had significant positive association with harvest index, grain yield panicle^{-1}, filled grain yield panicle^{-1}, productive tillers plant^{-1}, harvest index and filled grains panicle^{-1} were the major yield contributing traits to be given selection pressure for improving yield in rice.

Key words : Rice, character association, path analysis, yield and yield attributing traits.

In rice breeding strategies worldwide, attempts are being made to break the yield barrier. The grain yield is a complex character dependant on many component characters and it responds poorly to the direct selection. The knowledge on the association between grain and is component characters and their direct and indirect on grain yield will be helpful for the improvement of grain yield. The present study was, therefore, undertaken to understand the association among grain yield and its component characters components on the grain yield in rice.

MATERIALS AND METHODS

The experimental material for the present investigation comprised three lines viz., IET 13846 (L_1), IET 15391 (L_2) and IET 11819 (L_3) used as females; ten testers viz., Pusa Basmati-1 (T_1), Taraori Basmati (T_2), Kasturi (T_3), Basmati 370 (T_4), Mahi Sugandha (T_5), Pakistani Basmati (T_6), IR 64 (T_7), Ratna (T_8), Suraksha (T_9) and Naredra 359 (T_{10}) used as males and 30 hybrids obtains from line x tester mating design. These 30 F_1s along with 13 parents were planted in a randomized block design with three replications and Agricultural Research Station, Ummedganj, Kota (Rajasthan) during *kharif* 2001, under irrigated transplanted condition. Each plot consisted of single row of 5.0 m length with spacing of 20 x 15 cm. The observations were recorded on ten randomly selected plants from each treatment in each replication for 15 characters viz., days to 50% flowering, days to maturity, plant height, productive tillers plant^{-1} panicle length, primary branches panicle^{-1}, filled grains panicle^{-1}, unfilled grains panicle^{-1}, spikelet fertility (%), biological yield plant^{-1}, harvest index, 1000-grain weight, grain yield panicle^{-1} and grain yield plant^{-1}. The mean values were used for the analysis of variance. The correlation coefficient and path analysis were carried out following the methods of Al-Jibouri *et al.* (1958) and Dewey Lu (1959), respectively.

MATERIALS AND METHODS

The analysis of variance revealed highly significant differences among the genotypes for all the characters studied, indicating the existence of considerable genetic variation in the experimental material. The genotypic and phenotypic correlation in the experimental material. The genotypic and phenotypic correlation coefficients were slightly higher than the corresponding phenotypic correlation coefficients for most of the character pairs, indicating a strong inherent association between these characters. Grain yield palnt^{-1}, filled grains panicle^{-1} and productive tillers plant^{-1} at grain yield panicle^{-1} filled grains panicl^{-1} and productive tilers plant^{-1} at both genotypic and phenotypic levels, suggesting that the selection for these traits is likely to improve the grain yield. Similar findings were also reported by Meenakhi *et al.* (1999) and Nayak *et al.* (2001) for grains panicle^{-1} and Singh and Singh (2002) and Khedikar *et al.* (2004) for number of panicles plant^{-1}.

Table 1. Estimates of genotypic and phenotypic correlation coefficients among yield attributing characters in rice

Characters	Days to marutity	Plant height (cm)	Productive tillets plant^{-1}	Panicle length (cm)	Primary branches panicle^{-1}	Secondary branches panical^{-1}	Filled grains panical^{-1}	Unfilled grains panical^{-1}	Spikelet fertility (%)	Biological yield plant^{-1} (g)	Harvest index (%)	1000-grain weight (g)	Grain yield panicle^{-1} (g)	Grain yield plant^{-1}
Days to 50 r_g	0.97**	0.51**	0.31**	-0.10	-0.20	-0.13	-0.28	-0.30	0.00	0.61**	-0.50**	0.38*	-0.29	0.06
% flowering r_p	0.95**	0.50**	0.30*	-0.10	-0.20	-0.12	-0.28	-0.30	0.00	0.61**	-0.49**	0.38*	-0.29	0.06
Days to r_g		0.48**	0.38*	-0.12	-0.25	-0.20	-0.27	-0.27	-0.02	0.66**	-0.56**	0.37*	-0.40**	-0.12
maturity r_p		0.47**	0.37*	-0.12	-0.25	-0.20	-0.27	-0.27	-0.02	0.65**	-0.55**	0.36*	-0.39**	-0.11
Plant height r_g			0.02	0.12	-0.27	-0.27	-0.04	-0.19	0.48**	-0.40**	0.31*	-0.06	-0.06	-0.14
(cm) r_p			0.02	0.12	-0.27	-0.27	-0.27	-0.04	-0.19	0.48**	-0.40**	0.31*	-0.06	-0.14
Productive r_g				-0.19	-0.21	0.00	0.08	-0.17	0.16	0.54**	-0.14	0.01	0.59**	0.3*
tillers $_g$lant^{-1} r_p				-0.19	-0.21	0.00	0.08	-0.17	0.16	0.54**	-0.14	0.01	0.59**	0.32
Panicle legnth r_g					0.34*	0.34*	0.44**	0.11	0.25	-0.05	0.18	-0.25	0.39**	0.28
(cm) r_p					0.33*	0.34*	0.43**	0.11	0.24	-0.05	0.18	-0.25	0.38*	0.27
Primary r_g						0.59**	0.64**	0.28	0.25	-0.2.7	0.35*	-0.28	0.41**	0.28
branches r_p						0.59**	0.64**	0.28	0.24	-0.26	0.35*	-0.28	0.40**	0.28
Secondary r_g							0.59**	0.25	0.26	-0.06	0.21	-0.41**	0.22	0.28
branches r_p							0.59**	0.25	0.26	-0.06	0.21	-0.41**	0.22	0.28
panicle^{-1} r_g														
Filled grains r_p								0.29	0.48**	-0.17	0.40**	0.59**	0.29	0.42**
panicle^{-1} r_g								0.29	0.48**	-0.17	0.40**	0.59**	0.28	0.42**
Spikelet r_p									-0.65**	-0.26	0.38*	-0.35*	0.41**	0.28
fertility (%) r_g										0.06	-0.02	-0.15	-0.11	0.05
Biologycal r_p											-0.77**	0.43**	-0.54**	-0.11
yield plant^{-1}(g) r_g											-0.77**	0.43**	-0.53**	-0.11
Harvest index r_p												0.50**	0.70**	0.69**
(%)														
1000-grain r_g												0.50**	0.69**	0.69**
weitht (g) r_p													-0.21	-0.25
Grain yield r_g														0.55**
panicle^{-1} (g) r_p														0.55**

*and ** significant at P=0.05 and 0.01, respectively.

Table 2. Direct (diagonal) and indirect effects of yield attributing characters on grain in rice

Characters	Days to 50% flowering	Days maturity	Plant height (cm)	Productive tillers plant^{-1}	Panicle length (cm)	Primary branches panical^{-1}	Secondary branches panical^{-1}	Filled grains panical^{-1}	Unfilled grains panical^{-1}	Spikelet fertility (%)	Biologycal yield plant^{-1} (g)	Harvest index (%)	1000-grain weight (g)	Grain yield plant^{-1} (g)	Grain yield plant^{-1} (g)
Days to 50% flowering	**0.0654**	-0.2334	-0.0650	0.2801	-0.0073	-0.0009	0.0052	0.0330	-0.0427	0.0002	0.0704	-0.0802	0.0038	-0.884	-0.0599
Day to maturity	0.2561	**-0.2419**	-0.0611	0.3449	-0.0087	-0.0011	0.084	0.0318	-0.0391	-0.0026	0.0754	-0.0901	0.0037	-0.3910	-0.1157
Plant height (cm)	0.1341	-0.1149	**-0.1287**	0.0170	0.0085	-0.0012	0.0114	0.0318	-0.0063	-0.0248	0.0551	-0.0652	0.0031	-0.0623	-0.1424
Productive tillers plant^{-1}	0.0815	-0.0915	-0.0024	**0.9119**	-0.0134	-0.0010	-0.0001	-0.0088	-0.0246	0.0206	0.0623	-0.0232	0.0001	-0.5860	0.3255*
Panicle length (cm)	-0.0273	0.0295	-0.0154	-0.1718	**0.0710**	0.0015	-0.0142	-0.0512	0.0157	0.0324	-0.0062	0.0297	-0.0025	0.3868	0.2780
Primary branches panicle^{-1}	-0.0532	0.0612	0.0347	-0.1958	0.0238	**0.0044**	-0.0247	-0.0754	-0404	0.0324	-0.0305	0.0573	-0.0028	0.4068	0.2785
Secondary branches panicle^{-1}	-0.0334	0.0488	0.0351	0.0032	0.0242	0.0026	**-0.0417**	-0.0693	0.0352	0.0344	-0.0069	0.0339	-0.0041	0.2208	0.2830
Filled grains panicle^{-1}	-0.0748	0.0649	0.0349	0.0690	0.0311	0.0029	-0.0247	**0.1169**	0.0448	0.0639	-0.0192	0.0639	-0.0059	0.2820	0.4159**
Unfilled grains panicle^{-1}	-0.0794	0.0664	0.0057	-0.1569	0.0078	0.0013	-0.0103	-0.0368	**-0.1427**	-0.0863	-0.0303	0.0613	-0.0035	0.4021	0.2838
Spikelet fertility (%)	0.003	0.0048	0.0242	0.1428	0.0175	0.0011	-0.0109	-0.0567	-0.0934	**0.0318**	0.0072	-0.0036	-0.0015	-0.1118	0.0519
Biological yield plant^{-1} (g)	0.1626	-0.1587	-0.0617	0.4945	-0.0038	-0.0012	0.0025	0.0195	-0.0376	0.0082	**0.0150**	-0.1249	0.0043	-0.5313	-0.1126
Harvest index (%)	-0.1317	0.1347	0.0519	-0.1309	0.0130	0.0016	-0.0087	-0.0462	0.0541	-0.0029	-0.0888	**0.1617**	-0.0050	0.6889	0.6916**
1000-grain weight (g)	0.1019	-0.088	-0.0405	0.0125	-0.0178	-0.0012	0.0171	0.0387	-0.0497	-0.0194	0.0496	-0.0816	**0.0100**	-0.2116	-0.2510
Grain yield panicle^{-1} (g)	-0.0775	0.0957	0.0081	-0.5410	0.0278	0.0018	-0.0093	-0.0334	0.0581	-0.0149	-0.0618	0.1128	-0.0021	**0.9877**	0.5521**
Residual effect	0.0089														

*and ** significant at P=0.05 and 0.01, respectively.

Inter-correlation among yield components revealed positive and significant association of productive tillers plant^{-1} with biological yield plant^{-1} and grain yield panicle^{-1}. This was in conformity with the findings for Surek *et al.* (1998) and Singh and Singh (2002) for biological yield plant^{-1}. Filed grains panicle^{-1} expressed positive and significant correlation with spikelet fertility (%), panicle^{-1} expressed positive and significant correlation with spikelet fertility (%), harvest index and 1000-grain weight; confirming the earlier findings of Meenakshi *et al.* (1999) for harvest index. Harvest index showed positive and significant association with 1000-grain weight and grain yield panicle^{-1} confirming the results of Surek *et al.* (1998) for 1000-grain weight.

The direct and indirect effects of different yield components on grain yield plant^{-1} at the genotypic level are presented in Table 2. Among the yield components, grain yield panicle^{-1} showed maximum direct on grain yield plant^{-1}. It was followed by productive tillers plant^{-1}, harvest index and filled grains panicle^{-1} and, hence, direct selection through these characters is more effective. Similar results were also reported by Ibrahim *et al.* (2001) for harvest index and Meenakshi *et al.* (1999) for biological yield plant^{-1} and harvest index. Days to maturity, chaffy grains panicle^{-1} plant height and secondary *et al.* (2001) and Kedikar *et al.* (2004) also reported negative direct of plant height on the grain yield palnt^{-1}. The effect of residual factor (0.0089) on grain yield plnat^{-1} was negligible thereby suggesting that the characters studied were sufficient to contribute towards grain and there is no need for any other additional character to be studied.

From this study, it can be concluded that grain yield panicle^{-1}, harvest index, productive tillers plant^{-1} and filled grain panicle^{-1} were the major yield contributing traits through which high yielding genotypes of rice may be selected.

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STUDIES ON INFLUENCE OF BIOFERTILIZERS AND BIOREGULATORS ON FLOWERING, YIELD AND FRUIT QUALITY OF STRAWBERRY CV. SWEET CHARLIE

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ABSTRACT

Experiment was conducted to study the response of biofertilizers and bioregulators on strawberry crops. Results indicated that dual inoculation of *Azotobactor* and *Azospirillum* with 60 kg nitrogen/ha in conjunction with 100 ppm GA_3 proved most effective in increasing fruit set, early flowering, yield and also have a significant improvement in fruit quality i.e. berry size, weight and volume. The maximum TTS, total sugar and ascorbic acid content were obtained with the same treatment combination, however, the effect on acidity and TSS/acid ratio was found to be non-significant.

Key words : Biofertilizer, bioregulator, yield, fruit quality, strawberry.

The strawberry plant is a herbaceous, perennial and having shallow root system, comes to flowering after about four months. In this short growing period the plant makes only limited vegetative growth, with the result that the yield as well as the fruit quality are poor. Beneficial effects of bilfertilizers and bioregulators on crop growth are well established. If they are used in association with chemical fertilizers, the expected yield per unit may be increased. Nitrogen fixing bacteria not only increased the availability of applied nutrients to the plants but also synthesized some plant growth regulators, however occasionally some of the plant bioregulators are needed to be supplemented exogenously for additional stimulus for short duration crop like strawberry. The present study was undertaken to assess the most suitable combination of biofertilizers, bioregulatores and nitrogen levels in enhancing the yield and fruit quality of strawberry.

MATERIALS AND METHODS

The present study was conducted at Vegetable Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varansi, during 2002-2004. The soil of the experimental field was sandy loam; the available N, P and K were in medium range, the soil was neutral in reaction. *Azotobacter* or *Azospirillium* or dual inoculation (120 $kgha^{-1}$), without nitrogen, 50% N of the standard dose and 75% N of the standard dose were given to strawberry cv. Sweet Charlie. Simultaneously a separate experiment was conducted using foliar application of GA_3, NAA and BA@ 50ppm and 100ppm each, one month after planting. To study the effect of nitrogen fixing bacteria and plant bioregulators, an experiment was conducted by selecting two best treatments on the basis of firsts year observation from both the experiment. The various combinations of nitrogen fixing bacteria and plant bioregulators were:- T1- recommended dose of NPK, T2-water sprays, T3-*Azotobacter*+*Azospirillum*+50% N of the recommended dose, T4-*Azotobacter* + *Azospirillum* + 75% N of the recommended dose, T5-100ppm GA_3, T6-100ppm BA, T7-*Azotobacter* +*Azospirillum*+75% N of the recommended dose + 100ppm GA_3, T8-*Azotobacter*+*Azospirillum*+N of the recommended dose + 100ppm BA, T9-*Azotobacter*+*Azospirillum*+50%N of the recommended dose + 100ppm GA_3, T10-*Azotobacter*+*Azospirillum* 50% N of the recommended dose + 100ppm BA. Twenty runner plants were planted in the month of September, in raised bed at a distance of 25cm x 50cm. The experiment was laid out in the randomised block design.

Table 1. Effect of biofertillizers and plant bioregulators on flowering, fruit set, and yield of strawberry cv "Sweet Charlie"

Treatments	Days taken to produce first flower	Duration of flowering (Days)	Number of flowers plant^{-1}	Per cent berry set	Yield (qha^{-1}) (%)
T1=Control (Standard dose of NPK)	118.32	72	23.68	75.60	86.13
T2=Control+Water Spray	118.12	70	23.21	75.68	86.52
T3=*Azotobacter*+*Azospirillum*+75%N of the standard dose	113.42	77	30.58	79.36	91.86
T4=*Azotobacter*+*Azospirillum*+50% N of the standard dose	114.85	74	28.32	77.66	90.69
T5=GA$_3$ 100 ppm	115.89	78	32.10	81.77	91.13
T6=BA 100 ppm	118.22	75	29.17	79.36	89.48
T7=*Azotobacter*+*Azospirillum*+75%N of the standard dose+GA$_3$ 100 ppm	113.15	85	35.36	82.38	93.49
T8=*Azotobacter*+*Azospirillum*+75%N of the standard dose+BA 100 ppm	115.72	83	31.62	80.62	92.38
T9=*Azotobacter*+*Azospirillum*+50% N of the standard dose+GA$_3$ 100 ppm	113.75	91	38.78	84.28	94.26
T10=*Azotobacter*+*Azospirillum*+50% N of the standard dose+BA 100 ppm	114.85	86	35.62	80.86	91.32
Mean	115.62	79	30.84	79.74	90.72
C.D. (0.05)	NS	7.2	3.14	2.60	1.96

Table 2. Effect of biofertillizers and plant bioregulators on Phsysical characteristics of strawberry fruits cv "Sweet Charlie"

Treatments	Berry length (mm)	Berry breadth (Mm)	Berry weight (g)	Berry volume (cc)	Number of achenes cm^{-2}
T1=Control (Standard dose of NPK)	37.80	25.88	12.78	10.68	13.61
T2=Control+Water Spray	37.79	25.80	12.16	10.65	13.67
T3=*Azotobacter*+*Azospirillum*+75%N of the standard dose	40.35	25.86	16.14	12.20	11.35
T4=*Azotobacter*+*Azospirillum*+50% N of the standard dose	38.86	27.38	12.08	10.81	13.33
T5=GA$_3$ 100 ppm	39.26	27.79	12.38	11.38	11.72
T6=BA 100 ppm	39.59	27.57	12.23	11.21	12.12
T7=*Azotobacter*+*Azospirillum*+75%N of the standard dose+GA$_3$ 100 ppm	43.38	28.42	16.62	12.72	9.52
T8=*Azotobacter*+*Azospirillum*+75%N of the standard dose+BA 100 ppm	41.24	28.73	15.12	12.65	10.16
T9=*Azotobacter*+*Azospirillum*+50% N of the standard dose+GA$_3$ 100 ppm	45.36	28.65	16.75	13.75	9.31
T10=*Azotobacter*+*Azospirillum*+50% N of the standard dose+BA 100 ppm	39.38	28.29	13.75	11.82	12.36
Mean	40.30	27.80	14.00	11.78	11.81
C.D. (0.05)	3.48	NS	0.19	1.28	1.01

Table 3. Effect of biofertillizers and plant bioregulators on Chemical characteristics of strawberry fruits cv "Sweet Charlie"

Treatments	TSS (^{0}B)	Acidity (%)	TSS/ acid ratio	Total sugars (%)	Ascorbic acid (mg/100g fresh berries
T1=Control (Standard dose of NPK)	7.96	0.830	9.24	7.87	53.81
T2=Control+Water Spray	7.94	0.829	9.20	7.85	53.77
T3=*Azotobacter*+*Azospirillum*+75%N of the standard dose	8.36	0.843	9.30	8.20	56.53
T4=*Azotobacter*+*Azospirillum*+50% N of the standard dose	8.22	0.835	9.22	8.06	55.86
T5=GA$_3$ 100 ppm	8.18	0.833	9.20	8.11	56.64
T6=BA 100 ppm	8.12	0.831	9.16	8.10	56.25
T7=*Azotobacter*+*Azospirillum*+75%N of the standard dose+GA$_3$ 100 ppm	8.87	0.848	9.36	8.50	59.06
T8=*Azotobacter*+*Azospirillum*+75%N of the standard dose+BA 100 ppm	8.83	0.842	9.28	8.46	57.83
T9=*Azotobacter*+*Azospirillum*+50% N of the standard dose+GA$_3$ 100 ppm	8.96	0.837	9.17	8.55	59.22
T10=*Azotobacter*+*Azospirillum*+50% N of the standard dose+BA 100 ppm	8.27	0.835	9.12	8.16	56.23
Mean	8.37	0.836	9.22	8.18	56.52
C.D. (0.05)	0.13	NS	NS	0.15	1.61

Observations on commencement of flowering, number of flowers per plant, fruit set, fruit size, weight, fruit volume and yield (q ha^{-1}) were recorded. TSS was recorded ascorbic acid were calculated by the method as described in A. O. A. C. (1970). The TSS/acid ratio was calculated by dividing TSS by titratable acidity.

RESULTS AND DISCUSSION

Different treatment combination positive effect on flower formation, fruit set had and thus increased the total yield. Though various treatment combinations had non-significant effect on the commencement of the flowering but took less days as compared to control. Duration of flowering (91 days) as well as total number of flower per plant (38.78) were found maximum with treatment combinations of *Azotobacter* + *Azospirillum* + 50% N of the recommended dose +100 ppm GA$_3$ application, which also resulted highest fruit set (84.28%) and yield (94.26 g ha^{-1}). Although all the treatments given significantly higher yield as compared to the control. This increased fruit set, which resulted higher yield due to the fact that nitrogen fixer not only increased the availability the availability of nitrogen to the plant roots but also increased their translocation from root to flower through plants foliage. Simultaneously synthesis of bioregulator and exogenous application of GA$_3$ shifted the endogenous balance between promoters and inhibitors in favour of fruit forming processes (Goldwine, 1986). The increased percent berries set in the present studies are due to the cumulative effect of biofertilizers, nitrogen and the application of GA$_3$. It is also evident from the data given in Table 2 that the increased fruit length (45.36 mm), weight (16.75 g) and volume (13.75 cc) were obtained when plants were dual inoculated with *Azotobactor* and *Azospirillum* along with 50% nitrogen of the standard dose and treated with 100 ppm GA$_3$, however, the minimum number of achenes (9.31 cm^{-2}) were recorded with the same treatment combination. Fruit size and weight are highly correlated with dry matter content and balance level of hormone, and the *Azotobacter* and *Azospirillum* is known for accumulation of dry matter and their translocation (Parvatham and Vijayan, 1989), as well as favour synthesis of different growth regulators (Awashi *et al.*, 1998), exogenous application of GA_3 make the balance between inhibitors and promoters. The minimum number of achenes (cm^{-2}) was due to the large fruit size under same treatment combinations. These findings are in conformity with the findings of Hansen (1989), who reported that larger fruits contained lesser of achenes. An inquisition of data presented in Table 3 revealed that combination of biofertilizer and bioregulator have significant effect of chemical characters of berry. The maximum TSS (8.96 ^{0}B), total sugar (8.55%) and ascorbic acid (59.22 mg/100g) content were obtained when plants were dual inoculated with *Azotobacter* and *Azospirillum* along with 50% nitrogen of the standard dose and treated with 100 ppm GA_3, However, different treatment combinations have failed to show significant effect on the titratable acidity and TTS/acid ratio of the fruits. The application of nitrogen fixing bacteria and GA_3 with lower dose of nitrogen application might have exhibited regulatory role on the absorption and translocation of various metabolites, in which carbohydrates are most important which affects the quality of fruits. During ripening of fruits the carbohydrates reserves of the root and stem are drawn upon heavily and hydrolysed into sugars. Kumarswamy and Madalageri, 1990 also reported the similar results.

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GROWTH DYNAMICS OF INTERCROPPING SYSTEM IN CASTOR (*RICINUS COMMUNIS* L.) UNDER IRRIGATED ECOSYSTEM

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ABSTRACT

A field experiment was conducted to select suitable method of planting and intercropping with castor. Paired row planting of castor (60/120 cm x 60 cm) significantly improved the growth parameters (plant height, DMA, CGR, NAR, LAI), yield attribute (branches plant^{-1}, length of primary spike, capsule plant^{-1}, seed weight plant^{-1}, 100 seed weight) and the yields (seed, stalk and biological). Significantly higher values of growth parameters (plant height at harvest, DMA at 70, 120 and 180 DAS, CGR between 40-70 DAS and 70-120 DAS, LAI and yield attributes were recorded under paired planting of castor with greengram followed by castor+blackgram and castor+clusterbean. Maximum total seed yield and also stalk and biological yields of castor were recorded under castor+greengram intercropping system which was significantly higher over castor+ sesame intercropping system. Significantly higher castor equivalent yield (49.55 q ha^{-1}) was realised under castor+greengram intercropping system over castor+ clusterbean and castor+sesame but found at par with castor+blackgram.

Key words : Planting method, intercropping, growth dynamics, DMA, LAI, CGR, NAR.

Castor (*Ricinus communis* L.) is an important non edible oil seed crop of India being cultivated in 6.15 lacs hectares with a production of 5.90 lacs tones (FAO, 2003). In Rajasthan castor occupies 0.26 lacs hectare areas with the production of 0.22 lac tonnes. Among the different production factors, important of planting methods is considered as a major factor on determining growth and yield of castor (Gauda Reddy *et al.*,1975).

Being a widely spaced crop long duration and initial slow growth in nature, castor offers good scope for intercropping. Advantage of intercropping in castor can be increased by reorienting crop geometry for better availability of solar energy (Willey, 1979) and putting suitable intercrops. Legume crops may be better choice owing to beneficial effect of fixing atmospheric nitrogen and thereby some extra nitrogen was perhaps made available to the castor to utilize more efficiently beyond 90 DAS to harvest of castor. Additional advantage of nitrogen might have resulted in overall development of the crop in terms of plant height, DMA, branches and leaves per plant. Ramanathachetty (1983) already stated that legume fix atmospheric N and buildup about 20 to 50 kg N ha^{-1} soil N which can be utilized by companion crop of long duration nature. Looking to good proposal of castor in irrigated ecosystem of Southern Rajasthan this was conducted to realize higher net return.

MATERIALS AND METHODS

A field experiment was conducted during rainy seasons of 2001-2002 and 2002-2002 at the Agronomy Farm, Rajasthan College of Agriculture, Udaipur. The soil was clay loam having bulk density 1.40 mg m^{-3} with pH 8.0. The soil was medium in organic carbon (0.73%), available nitrogen (279.30 kg ha-1) and phosphorus (22.4 kg ha^{-1}) and high in available K (328.4 kg ha^{-1}). The experiment was laid out in randomized block design with four methods of castor planting i.e., uniform row planting at 90 cm x 60 cm, 120 cm x 45 cm and paired row planting at 60/120 cm x 60 cm and 80/160 cm x 45 cm and five intercropping systems i.e. sole castor, with greengram, blackgram, clusterbean and sesame. There were four additional treatments of sole crop greengram, blackgram, clusterbean and sesame with three replications. Castor var. GCH 4, greengram var. K-851, blackgram var. T-9, clusterbean var. RGC-936 and seasame var. RT-46 were sown on 18 and 19 July in 2001 and 2002, respectively. The recommended seed drate of casto (12 kg ha^{-1}), greengram and blackgram (15 kg ha^{-1}), clusterbean (20 kg ha^{-1}) and seasame (3 kg ha^{-1}) were used.

Recommended doses of fertilizer 80 kg N ha^{-1} and 50 kg P_2O_5 ha^{-1} were applied to the castor. Castor was weeded manually twice 20 and 40 DAS. During the crop season there was 362.7 mm rainfall in 2001-2002 and 2002-2003, respectively. In all these were 5 pickings 120, 150, 180, 210 and 240 days after sowing, respectively.

Different growth parameters i.e. DMA, CGR, NAR, LAI and the yields were recorded for treatment evaluation.

RESULTS AND DISCUSSION

Growth parameters

Effect of planting methods

Paired row planting of castor (60/120 cm x 60 cm) recorded significantly higher plant height, dry matter accumulation at successive growth stage (70, 120 and 180 DAS), CGR between 40-70 DAS and 70-120 DAS, NAR between 40-70 DAS over uniform row planting (90 cm x 60 cm, 120 cm x 45 cm) and paired row planting at 80/160 cm x 45 cm. LAI at all growth stage except 40 DAS were significantly higher over uniform row planting at 120 cm x 45 cm, however found at par with uniform row planting (90 cm x 60 cm). Paired row planting of castor could intercept more solar radiation and utilize it efficiently which is reflected by improvement in CGR and NAR and ultimately plant height and DMA at successive growth stage (Table 1 and Fig. 1). This finding is in line with that of Kantesh *et al.* (1997) in respect of plant height, DMA, LAI and CGR of sugarcane under paired row planting of 60/120 cm.

Effect of intercropping

Maximum plant height of castor (206.70 cm) was recorded in castor + greengram intercropping system which was significantly higher over no intercropping (11.0%) and castor + sesame (12.7%) per plant. Dry matter accumulation was observed higher 70 and 180 DAS under castor + greengram which was statistically superior over castor+ sesame. However, at 120 DAS growth stage castor + greengram intercropping exhibited significantly higher dry matter accumulation by 6.5 and 21.8 per cent over no intercropping and castor + sesame respectively. CGR was suppressed in castor + sesame intercropping system between 40-70 DAS and 70-120 DAS as compared to other intercropping system. Further NAR was not found to very significantly due to intercropping system. LAI of castor at 70, 120 and 180 DAS was significantly higher with sole castor and castor + legumes over castor + sesame (Table 1). This can be attributed to the that legume intercrops having comparatively short span of life were harvested 60-80 DAS and there was no competition for nutrients, moisture and solar radiation 60 DAS. The castor growth under competition free environment result to higher number of branches plant^{-1} and consequently LAI. These result of LAI of pigeon pea + blackgram intercrop system are close conformity to those reported by Subramanian and Venkateswarlu (1989).

Yield attributes and yield

Effect of planting methods on castor

Paired row planting of castor (60/120 cm x 60 cm) increased yield attributes i.e. branches plant^{-1}, length of primary spike, number of capsule plant^{-1}, seed weight plant^{-1} and 100-seed weight significantly (Table 2). These increases in yield attributes could be ascribed to significant increases in growth parameters of the crop under paired planting of castor (60/120 cm). This system allows more interception of solar radiation by the crop canopy on account of higher inter paired row space. This might have enabled the crop to maintain higher net photosynthetic rate and resulted in greater dry matter production per unit area.

Paired row planting of castor (60/120 cm x 60 cm) registered maximum seed, stalk and biological yield (Fig. 2). It appears that higher value of NAR, CGR, LAI, DMA under this planting pattern reflected in enhanced vigour and

Table 1. Effect of planting methods and intercropping on growth dynamics of castor (pooled data of two years)

Treatments	Plant height (cm)	Dry matter accumulation (g plant^{-1})				Leaf area index				CGR (gm^{-2} day^{-1})	NAR (gm^{-2} day^{-1})	
		40 DAS	70 DAS	120 DAS	180 DAS	40 DAS	70 DAS	120 DAS	180 DAS	between 40-70 DAS	between 70-120 DAS	between 40-70 DAS
Methods of castor planting												
90 X 60	191.1	23.2	73.5	191.5	381.0	0.238	0.494	1.218	1.821	3.10	4.37	8.97
120 X 45	187.2	22.5	68.6	173.8	341.3	0.236	0.467	1.137	1.705	2.85	3.90	8.56
60/120 X 60	205.5	24.9	81.8	208.9	408.7	0.242	0.509	1.226	1.854	3.52	4.71	9.91
80/160 X 45	202.0	23.8	76.5	193.3	386.4	0.240	0.503	1.221	1.840	3.25	4.33	9.29
C.D. (P=0.05)	8.52	NS	4.34	9.14	18.28	NS	0.0180	0.0370	0.0500	0.234	0.332	0.756
Intercropping												
None	186.3	23.4	75.9	192.6	384.30	0.238	0.504	1.214	1.812	3.24	4.32	9.28
Greengram	206.7	25.1	79.2	205.2	398.99	0.242	0.510	1.233	1.845	3.34	4.66	9.44
Blackgram	203.8	24.0	78.2	198.5	392.70	0.241	0.500	1.216	1.832	3.34	4.46	9.56
Clusterbean	202.1	23.7	76.6	194.8	387.99	0.239	0.492	1.217	1.826	3.27	4.37	9.42
Sesame	183.4	21.8	65.6	168.4	332.74	0.235	0.460	1.123	1.710	2.71	3.81	8.21
C.D. (P=0.05)	9.53	NS	4.85	10.22	20.43	NS	0.0210	0.0410	0.0560	0.262	0.372	NS

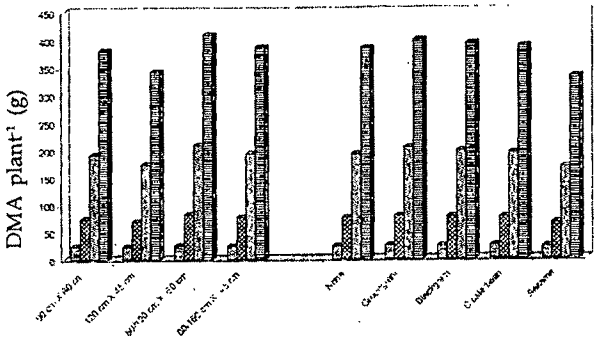

Fig. 1. Effect of planting methods and intercropping on dry matter accumulation by castor (Pooled)

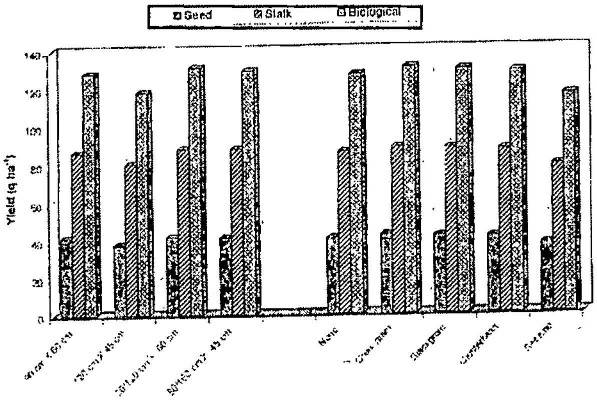

Fig. 2. Effect of planting methods and intercropping on seed, stalk and biological yield of castor (Pooled)

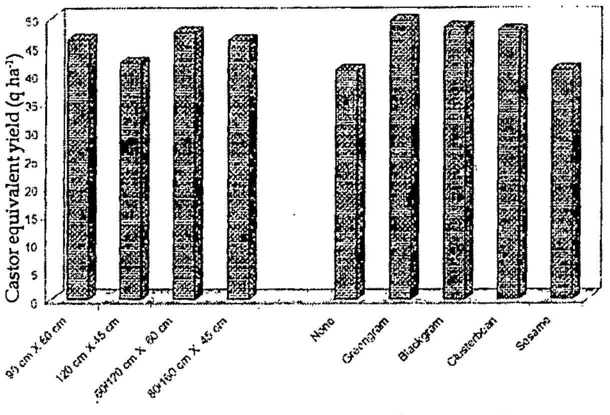

Fig. 3. Effect of planting methods and intercropping on castor equivalent yield (q ha^{-1}) (Pooled)

yield attributes which might have contributed in significantly higher seed stalk and biological yield of the crop. Singh (2004) observed remarkable improvement in yield of soybean in paired row system over alternate row system an account of enhanced vigour and plant growth because of greater LAI which eventually led to eventually led to enhanced dry matter accumulation. Further study seed yield of castor showed positive correlation with growth and yield attributing characters.

The correlation between seed yield and DMA 70, 120 and 180 DAS, CGR between 70-120 DAS, number of branches plant-1, length of primary spike, no. of capsule plant^{-1}, seed weight plant^{-1}, and 100 seed weight with correlation coefficient of 0.819, 0.820, 0.788, 0.751, 0.798, 0.743, 0.886, 0.876 and 0.807, respectively were recorded. Similar increased the seed yield by 0.322, 0.138, 0.070, 5.978, 4.058, 0.861, 0.11, 0.073 and 0.917 qha^{-1}, respectively (Table 3).

Effect of intercropping on castor

Branches plant^{-1}, length of primary spike, and seed weight plant^{-1} increased significantly under castor + greengram, castor+ blackgram and castor + clusterbean over no intercrop and castor + sesame. Further, castor+ sesame intercropping system reduced capsule plant^{-1} and 100-seed weight significantly as compared to rest of the intercropping system. The castor + greengram system gave the maximum seed yield, stalk and biological yields which were recorded significantly higher over castor + sesame intercropping system. Enhanced yield attribute which contributed favorably to photosynthetic efficiency might be on account of higher nitrogen status of soil because of additional advantage of nitrogen fixation by legume root nodules. These results are in agreement with those of Sharma (2002) who has reported increased number of capsule spike^{-1} in paired row, castor intercropped with greengram over sole castor.

Castor equivalent seed yield

Maximum castor equivalent seed yield under row planting (60/120 x 60 cm) could be ascribed to additive effects of seed yield of castor and intercrops (Table 2). The results are in

Table 2. Effect of planting methods and intercropping on yield attributes and yield of castor (pooled data of two years)

Treatments	Branches plant^{-1}	Length of primary spike (cm)	Capsule plant^{-1}	Seed weight plant^{-1}	100 Seed weight plant^{-1}	Yield (q ha^{-1}) Seed	Yield (q ha^{-1}) Stalk	Yield (q ha^{-1}) Biological	Castor seed equivalent yield (q ha^{-1})
Methods of castor planting									
90 X 60	7.70	36.98	267.77	251.35	30.31	41.56	86.40	127.96	46.23
120 X 45	7.08	34.53	242.31	216.30	27.96	37.83	80.30	118.14	42.20
60/120 X 60	8.18	39.80	289.89	270.48	32.18	41.84	88.29	131.14	47.50
80/160 X 45	7.88	39.16	276.25	254.78	31.05	41.37	88.09	129.46	46.12
C.D. (P=0.05)	0.36	1.45	9.94	16.03	1.38	1.33	4.13	5.08	1.45
Intercropping									
None	7.62	37.33	270.57	248.63	30.34	40.89	86.33	127.22	40.89
Greengram	8.09	39.33	278.80	270.95	31.66	42.45	88.56	131.01	49.55
Blackgram	7.97	38.55	273.89	261.50	31.34	41.62	87.98	129.60	48.36
Clusterbean	7.95	38.21	272.93	257.93	257.55	30.86	41.21	87.12	128.33
Sesame	6.90	34.67	241.56	202.51	27.69	37.10	78.86	115.96	40.94
C.D. (P=0.05)	0.40	1.62	11.11	17.92	1.54	1.48	4.62	5.68	1.62

Table 3. Effect of planting methods and intercropping on yield attributes and yield of castor (pooled data of two years)

S. No	Dependent variable	Independent variable	Correlation coefficient	Regression equation
1.	Seed yield (q ha^{-1})	DMA (g $plant^{-1}$) 70 DAS	0.819**	Y=16.473 + 0.322 X
2.	Seed yield (q ha^{-1})	DMA (g $plant^{-1}$) 120 DAS	0.820**	Y=14.048 + 0.138 X
3.	Seed yield (q ha^{-1})	DMA (g $plant^{-1}$) 180 DAS	0.788**	Y=13.960 + 0.070 X
4.	Seed yield (q ha^{-1})	CGR (g m^{-2} day^{-1}) between 70-120 DAS	0.751**	Y=16.873 + 5.978 X
5.	Seed yield (q ha^{-1})	No. of branches $plant^{-1}$	0.798**	Y=9.377 + 4.058 X
6.	Seed yield (q ha^{-1})	Length of primary spike (cm)	0.743**	Y=8.253 + 0.861 X
7.	Seed yield (q ha^{-1})	No. of capsule $palnt^{-1}$	0.886**	Y=10.284 + 0.113 X
8.	Seed yield (q ha^{-1})	Seed weight $plant^{-1}$	0.876**	Y=22.555 + 0.073 X
9.	Seed yield (q ha^{-1})	100-seed weight (g)	0.807**	Y=12.793 + 0.917 X

** Significant at 1 per cent level of probability

agreement with the findings of Sharma (2002). Higher castor equivalent seed yield under castor + legume intercropping system over sole castor and castor + seasame (Table 2 and Fig. 3). These results area in conformity with the findings of Gupta and Rathore (1993).

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EFFECT OF SOWING ENVIRONMENT AND NITROGEN LEVELS ON LIGHT INTERCEPTION AND ITS EFFICIENCY IN DRY MATTER PRODUCTION IN WHEAT CULTIVARS

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ABSTRACT

The field experiments were conducted at research farm of the Department of Agricultural Meteorology, CCS Haryana Agricultural University, Hisar. Five wheat cultivars : WH 542, PBW 343, UP 2338 Raj 3765 and Sonak were sown on 25th Novemeber, 10th and 25th December with four nitrogen levels viz., no nitrogen, 50, 100 and 150 per cent of recommended dose. Leaf area index, dry matter at anthesis and final dry biomass were measured at different growth stages. Photosynthetically active radiation was measured with line quantum sensor at different growth stages in all the treatments. Transmitted, refleced and absorbed photosynthetical active radiations were computed. Absorbed PAR in wheat decreased with delay in sowing. Wheat fertilized with 180 kg nitrogen/ha absorbed maximum photosynthetical active radiations. Delay in sowing adversely affected the radiation use efficiency of wheat crop. The cultivar PBW 343 was more efficient in radiation utilization in comparison with WH 542, UP 2338, Raj 3765 and Sonak. The maximum value of radiation use efficiency varied between 2.55 to 2.80 (1998-99) and 2.92 to 3.14 g/MJ (1999-2000). Radiation use efficiency explained around 65 per cent variability in leaf area index and dry biomass of wheat crop.

Key words : Photosyntheticaly active radiation, radiation use efficiency, wheat, sowing environments, transmitted, reflected, absorbed, nitrogen.

Solar radiation is the main source of energy for photosynthesis, the initial process that green plants use to convert carbon dioxide and water into simple sugars. Other plant processes convert these initial products of photosynthesis into dry matter. Photosynthetically active radiation (PAR) is the radiation in the particular waveband which excites chlorophyll molecules and other pigments and thus initiates the flow of energy required in photosynthesis. The ratio of PAR to total solar energy received at the surface is generally reported to be about 0.49 (Kailasnathan and Sinha, 1984). When a helathy crop receives adequate water and nutrients, dry matter production is mainly governed by solar energy available for photosynthesis.

Radiation use efficiency refers to the efficiency with which intercepted radiation energy is used for the production of biomass. Radiation interception depends mainly on the leaf area index (LAI) and canopy architecture. Patel *et al.* (1997) found that absorption of PAR was at peak during 50 per cent podding in pigeonpea. Nehra *et al.* (1996) reported that delay in sowing of toria (*Brassica campestris*) from first week of September to first week of October significantly increased the radiation use efficiency. Hall *et al.* (1995) studied radiation use efficiency of sunglower crops under different nitrogen levels and population densities. Higher light interception was reported by Kler *et al.* (1983) in bi-directional sowing of gram crop. Therefore, an attempt was made to study the PAR interception and its efficiency in dry matter production in wheat genotypes under different nitrogen levels and sowing environments.

MATERIALS AND METHODS

The field experiment was conducted during rabi seasons of 1998-99 and 1999-2000 at the research area of the Department of Agricultural Meteorology, CCS Haryana Agricultural University, Hisar (latitude : 29°10'N, longitude 75°46' E and altitude 215.2 m). The five wheat genotupes WH 542 (V_1), PBW 343 (V_2), UP 2338 (V_3), Raj 3765 (V_4) and Sonak (V_5) were sown on 25th November (D_1), 10th December (D_2) and 25th December (D_3) with four nitrogen levels : No nitrogen(N_0) 50 (N_1), 100 (N_2) and 150 per cent (N_3) of the recommended dose of 180 kg N/ha. The experiment was laid out in a split plot design with three replications. All other agronomic practices were followed as per package of practices recommended for wheat crop by the University. The leaf area was measured with leaf area meter (Licor-3100) at an interval of 15 days starting from 30 days after sowing onwards to physiological maturity. The plant samples taken for leaf area measurement were dried in oven at 65±5°C temperature till constant weight and weighed on an electric balance. The final seed yield was recorded after threshing the samples from all plots.

Line quantum sensor (LI-190 SB) was used to measure the photosynthetically active radiation (PAR) in the range of 400 to 700 nm at canopy level. The level. The reflected radiation was obtained by keeping the sensor inverted above the canopy and the sensor was also kept on ground across the rows diagonally to get transmitted radiation to the ground. The observations were recorded at different growth stages during 11:30-13:00 hours on clear days. The fraction of PAR intercepted (IPAR) by the crop was calculated as :

$$\text{IPAR} = (1-r)\ \text{PAR}$$

The fraction of PAR absorbed (APAR) is computed as :

$$\text{APAR} = (1-r-t)\ \text{PAR}$$

Where,

r & t = Reflected and transmitted PAR

The attenuation coefficient 'k' was calculated as per the method adopted by Monsi and Saeki (1953).

Daily solar radiation was computed by the expression :

$$Rs = RA\ (1-r)\ (a-b\ n/N)$$

Where,

Rs = Solar radiation received at the earth surface

RA = Solar radiation received out the atmosphere

r = Reflection coefficient (0.25)

a = 0.256; b = 0.56 (For Hisar, Bishnoi *et al.*, 1995)

n = Bright sunshine hours/day

N = Maximum possible hours of sunshine (List, 1964).

The daily PAR was calculated by multiplying RS values by 0.49 (Kailsnathan and Sinha, 1984) and converted into MJ/m². The daily IPAR was calculated as per the procedure adopted by Rosenthal and Gerik (1991).

The radiation use efficiency (RUE) was calculated as :

$$\text{RUE (g/MJ)} = \frac{\Sigma\text{DM (g/m}^2)}{\Sigma\text{IPAR (MJ/m}^2)}$$

Where,

EDM = Cumulative dry matter for a growth period.

EIPAR = Cumulative intercepted phosynthetically active radiations for the same growth period.

The correlation and regression analysis were carried out to study the relationship of growth and yield with radiation use efficiency.

RESULTS AND DISCUSSION

Intercepted PAR by different wheat genotypes was cumulated over different phenophases and depicted in Fig. 1 & 2, during 1998-99 and 1999-2000, respectively. Interception of PAR increased rapidly upto 75 DAS (days

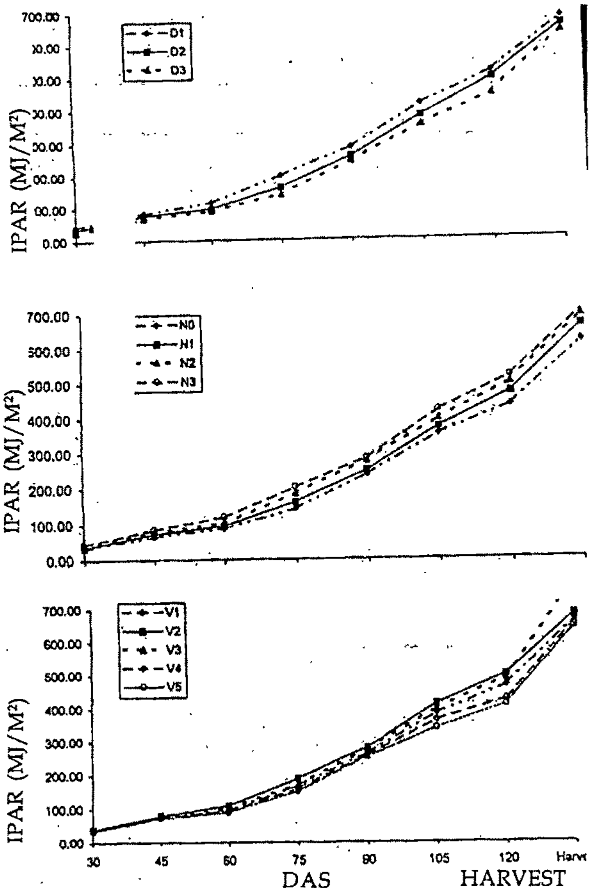

Fig. 1. Variation of cumulative intercepted photosynthetically active radiation (IPAR) under different treatments in wheat during 1998-99

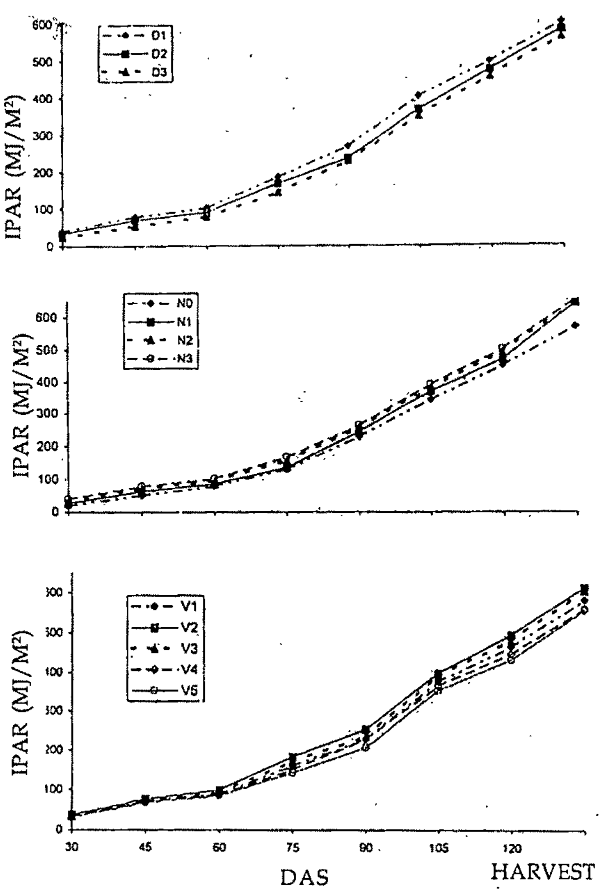

Fig. 2. Variation of cumulative intercepted photosynthetically active radiation (IPAR) under different treatments in wheat during 1999-2000

after sowing) and afterward it increased rapidly upto harvest in all the treatments.

Wheat crop sown on 25th November intercepted more PAR in comparison with wheat sown on ther dates. This might be due to higher leaf area index of wheat sown on this date. The application of nitrogen had also influenced the interception of PAR at all the growth stages. Sastri *et al.* (2000) reported that nitrogen fertilization significantly affected light interception. The wheat cultivar PBW 343 intercepted maximum PAR followed by UP 2338, WH 542, Raj 3765 and Sonak during whole growth period. This might be attributed to highest leaf area index produced by thes cultivar. T hese results are in confirmationwith the findings of Patel *et al.* (1997) in pigeonpea and Ram Niwas *et al.* (1999) in pearl millet.

The per cent values of transmitted, reflected and absorbed PAR at maximum leaf area index stage are presented in Table 1 during 1998-99 and absorbed PAR at maximum LAI stage were 81.7, 78.8 and 75.4 per cent in 25th November, 10th and 25th December, respectively during 1998-99 and 1999-2000. The corresponding values of absorbed PAR for second season were 80.4 (D_1), 73.6 (D_2) and 71.4 (D_3) per cent. The absorbed PAR increased with increase in nitrogen application due to direct effect of nitrogen application on UP 2338 WH-542, Raj 3765 and Sonak, respectively.

The transmitted and reflected PAR values varied among different sowing dates, nitrogen level and cultivars. Irrespective of all the treatments the PAR transmission varied nitrogen level and cultivars. Irrespective of all the

Table 1. Effect of different treatments on transmitted, reflected and absorbed photsynthetically active radiations (%) at maximum leaf area stage in wheat

Treatments	1998-99			1999-2000		
	Transmitted	Reflected	Absorbed	Transmitted	Reflected	Absorbed
D_1	11.4	6.9	81.7	12.9	6.8	80.4
D_2	14.2	7.0	78.8	17.7	8.7	73.6
D_3	17.1	7.5	75.4	20.0	8.5	71.4
N_0	17.2	8.9	73.9	17.5	10.2	72.4
N_1	15.2	7.5	77.3	17.4	8.5	73.9
N_2	12.5	6.3	81.1	16.2	7.4	75.8
N_3	12.1	5.8	82.1	16.4	5.9	76.4
V_1	13.2	6.9	80.0	16.7	7.7	75.7
V_2	10.8	6.1	83.1	15.3	7.0	77.8
V_3	12.6	6.3	81.0	17.5	8.0	74.0
V_4	13.7	7.7	77.6	16.4	9.8	73.8
V_5	16.7	8.7	74.6	18.6	9.6	71.0

treatments the PAR transmission varied between 10.8 to 20.0 per cent and PAR reflection varied between 5.8 and 10.2 per cent during maximum leaf area stage in both crop seasons. Ram Niwas *et al.* (1999) found that PAR interception was maximum in Pusa-23 (82.3 to 84%) and minimum in HHB-67 (71.6 to 79.5%) at maximum leaf area stage in pearl millet.

The radiation use efficiency (RUE) of wheat cultivars under various treatments are presented in Table 2 during 1998-99 and 1999-2000. The radiation use efficiency of wheat cultivars increased with growing period and attained maximum at 90 DAS and afterward decreased till harvest in all the treatments and in both seasons. The first sown wheat crop was more efficient in radiation utilizaton over later sown wheat crops. This was attributed to maximum PAR interception by first wheat sown crop. The decrease in RUE with delay in sowing of pearl millet was reported by Squire et al. (1984). The values increased with increase in nitrognen application in wheat crop. The maximum values of RUE were 2.67, 2.80, 2.60 and 2.55g/MJ in WH 542, PBW 343, UP 2338, Raj 3765 and Sonak, respectively during 1998-99. The corresponding value of RUE for the second season were 3.03, 3.14, 3.12, 2.93 and 2.92, respectively. Ghallagher and Biscoe (1978) reported that the RUE of wheat and barley was 2.2g/MJ.

The IPAR and radiation use efficiency were correlated with leaf area index, dry matter and yield. The correlation coefficients 'r' were higher in case of RUE in comparison with intercepted PAR. The simple regression model for leaf area index and dry mater based on RUE during maximum leaf area stage are of the from :

LAI = -0.275 + 1.39 RUE
R2 = 0.06

TDM = 210.01 + 340.60 RUE
R2 = 0.65

Where,

LAI = Leaf area index
TDM = Total dry matter (g/m2)
RUE = Radiation use efficiency (g/MJ)

The radiation use efficiency during maximum leaf area stage of wheat explained the variability upto 65 and 66 per cent in leaf area index and total dry matter production respectively.

Table 2. Effect of different treatments on radiation use efficiency (gMJ^{-1}) at various growth stages in wheat

Treatment	30 DAS		45 DAS		60 DAS		75 DAS		90 DAS		105 DAS		120 DAS	
	98-99	99-00	98-99	99-00	98-99	99-00	98-99	99-00	98-99	99-00	98-99	99-00	98-99	99-00
D_1	0.92	1.17	1.45	1.78	2.14	2.31	2.75	2.62	2.92	3.12	2.12	2.50	1.66	2.07
D_2	0.80	1.07	1.3	1.38	1.92	2.15	2.32	2.42	2.62	2.91	2.09	2.34	1.51	1.91
D_3	0.74	0.83	1.21	1.03	1.83	1.99	2.03	2.27	2.40	2.66	1.95	2.30	1.40	1.89
C.D. at 5%	0.07	0.08	0.09	0.36	0.13	0.26	0.28	0.20	0.27	0.25	NS	0.26	0.11	0.10
N_0	0.64	0.90	1.13	1.35	1.82	1.96	1.98	2.07	2.49	2.37	1.72	2.03	1.35	1.72
N_1	0.77	1.05	1.25	1.53	1.88	2.14	2.27	2.39	2.59	2.73	1.88	2.36	1.46	1.78
N_2	0.91	1.15	1.42	1.60	2.04	2.29	2.53	2.64	2.74	3.10	2.25	2.60	1.56	1.90
N_3	0.96	1.23	1.48	1.62	2.08	2.33	2.69	2.73	2.80	3.22	2.30	2.67	1.61	2.04
C.D. at 5%	0.05	0.05	0.06	0.22	0.08	0.19	0.16	0.32	0.15	0.34	0.16	0.30	0.10	0.12
V_1	0.82	1.05	1.32	1.47	1.97	2.20	2.4	2.41	2.67	3.03	2.06	2.31	1.50	2.02
V_2	0.86	1.05	1.32	1.47	1.97	2.20	2.4	2.41	2.67	3.03	2.06	2.31	1.50	2.02
V_3	0.83	1.09	1.36	1.50	2.02	2.16	2.49	2.55	2.73	3.12	2.08	2.39	1.54	2.06
V_4	0.81	1.03	1.28	1.42	1.91	2.13	2.25	2.31	2.60	2.93	2.00	2.28	1.47	2.01
V_5	0.77	1.03	1.26	1.41	1.87	2.10	2.20	2.30	2.55	2.92	1.95	2.26	1.46	1.98
C.D. at %	NS	0.02	0.02	NS	0.04	0.08	0.08	NS	0.13	0.12	0.08	NS	NS	0.04

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EFFECT OF LIME AND PHOSPHORUS ON YIELD AND NUTRIENTS UPTAKE BY MAIZE IN MOUNTAIN ACIDIC SOIL OF HIMACAHAL PRADESH

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ABSTRACT

A field experiment was conducted in maize-radish-onion cropping sequence. There were three levels of lime viz. 0, 1.54 and 0.08 t/ha (full lime requirement) and four levels of P viz. 0,13,26 and 39 kg/ha replicated three times. The results revealed that lime application significantly increased the yield of maize grain up to 3.08t/ha during both the years and stover duing second year. This increase in grain yield due to half and full lime requirement was 17 and 23 per cent during 1999 and 9 and 21 per cent during 2000 over no lime dose, respectively. During first year of the experimentation, the significant increase in grain yield was up to 39 Kg P/ha. However, during 2000, the response narrowed down to 13 Kg/ha. The per cent increase over no P dose was 13, 24 and 29 and 10, 18 and 24 per cent due to 13, 26 and 39 kg/ha during first and second year, respectively. The response of P on stover yield of maize was significant up to 26 Kg P/ha during both the years. Uptake of N, P and K by maize grain as well as stover increased significantly due to each level of lime up to 30.8t/ha and P up to 39 kg/ha except during first year in P uptake by grain, where increase was up to 26 kg P/ha and K uptake where lime effect was up to half of the requirement instead of full dose.

Key world : Maize, lime, phosphorus, yield, uptake, Alfisol.

Maize is one of the important cereal crop in Himachal Prasesh and country. About 25-30 per cent (Bishnoi, 1979) of the net cultivated area in H.P. is under acidic soils with high amounts of exchangeable aluminum, low pH, deficiency of P and low availability of bases which eventually result in still lower maize yield (Dixit and Sharma, 1993). Poor availability of P is one of the dominant factor for low productivity of crops in this region, because P becomes immobile and unavailable to plants due to low pH and dominance of active forms of Al and Fe that affects the P and make it unavailable (Sharma and Tripathi, 1984). Soil acidity and P availability are closely related and magnitude and proportion different components of acidity depend on lime application.

The information on effect of P with lime on yield, uptake and nutrient buildup in soil taking maize as test crop particularly in maize-radish, onion cropping sequence, that too in mountain acid soils is very meager. The present experiment was therefore, conducted on productivity and nutrients uptake by maize in acidic soils of Western Himalayas.

MATERIALS AND METHODS

Field experiment was conducted during 1999 and 2000 at CSK HPKV, Palampur. There were twelve treatments consisting of four levels of P (0, 13, 26 and 39 kg P/ha) and three of lime (0, 1/2 LR and full lime requirement-LR) replicated thrice in a randomized block design. The lime requirement of the soil was 3.08t/ha. Maize variety Parvati was grown as test crop in maize-radish-onion cropping sequence for two years. The sowing of maize crop was done 10.6.1999 and harvested on 27.2.1999 during first year. During second year, crop was sown on 19.6.2000 and harvested on 30.9.2000. recommended doses of N (125 kg/ha) and K (40 kg/ha) were applied in soil. All the K was applied at the time of sowing, whereas N was applied in three splits. Lime was applied only on first crop i.e. maize in above mentioned cropping sequence and in second year, the effect of lime was residual. But, the effect of phosphorus was direct in maize during both years. Grain and straw samples, collected at harvest of crop, were dried at 50°C, ground and digested in di-acid mixture (HNO_3:

$HClO_4$ 10:4) by volume and the extract was analysed for P and K determination. Phosphorus was analyzed by vanado molybdate coloured method (Jackson, 1967). In case of N determination in micro-Kjheldahl N distillation apparatus and K through flame photometer.

The post haves samples were analyzed for pH (Jackson, 1967), organic carbon (Walkley and Black, 1934), available N (Subhiah and Ajija, 1956), P (Olsen *et al.* 1954), and K (Merwin and Peech, 1951) by standard procedures.

Results and Discussion

Yield

The yield of maize grain increased significantly during both the years and response was significant with each dose of lime up to 3.08 t/ha level. The increase in grain yield due to half and full lime requirement was 17 and 23 per cent during 1999 and 9 and 21 per cent during 2000 over no lime dose, respectively (Tables 1 and 2). Application of P also increased the grain yield of the crop to a significant extent. During first year of the experimentation, the significant increase in grain yield was up to 39 Kg P/ha. However, during second year i.e. 2000, the response narrowed down to 13 Kg/ha. The reason for this may be that there may be the residual P in soil, so the response narrowed down to lower dose. The per cent increase over no P dose was 13, 24 and 29 and 10, 18 and 24 per cent due to 13, 26 and 39 Kg/ha during first and second year, respectively. Lime might have reduced acidity, improved base saturation pH, reduced the toxicity of elements like Al, Fe and Mn (Dixit and Sharma, 1993). Since, soil is acidic in reaction, therefore, there can be increase in productivity of crop due to lime application. Besides, lime has also a positive role to play in upgrading the granulation and microbial growth, which are responsible for decompositions of organic matter and mineralization of nutrients from the original source.

Like grain, stover yield increased due to lime addition upto full lime requirement during 2000. However, during 1999, the significant increase in its yield was reduced to half of the lime requirement (Tables 3 and 4). The response of P was significant up to 26 Kg/ha during both the years. Phosphorus is an essential nutrient being involved in strengthening of roots, cell division, elongation, production of ATP and various metabolic reactions and thereby improving the productivity of crops, therefore, this might have improved the yield of the crop.

Table 1. Effect of lime and P on maize grain yield (q/ha) (1999)

	P_0	P_{13}	P_{26}	P_{39}	Mean
L_0	37.6	44.8	51.4	55.6	47.4
$L_{1/2}$	47.2	53.6	58.8	62.4	55.5
L_1	53.6	58.2	61.2	60.8	58.4
Mean	46.1	52.2	57.1	59.6	
C.D. (P=0.05) L	2.0	P 2.4		PXL	4.0

Table 2. Effect of lime and P on maize grain yield (q/ha) (2000)

	P_0	P_1	P_2	P_3	Mean
L_0	24.8	28.0	30.4	32.2	28.8
$L_{1/2}$	27.2	30.2	32.8	35.2	31.4
L_1	32.2	34.4	36.0	37.2	35.0
Mean	28.1	30.9	33.1	34.9	
C.D. (P=0.05) L	2.4	P 2.8		PXL	NS

Grain and stover yield of maize increased significantly due to lime and P interaction effect, but it was significant only during first year. The P application increased grain yield significantly up to 39 Kg/P/ha at no lime, 26 KgP/ha at half of the lime requirement and 13 Kg P/ha full lime requirement. Increase in stover yield at no lime and half of the lime requirement was up to 26 Kg P/ha. However, at full lime requirement, a significant increase was recorded but only due to 13 Kg P/ha. However, at full lime requirement, a significant increase was recorded but only due to 13 Kg P/ha over P. At different P levels, lime response was upto 30.8 t/ha significant at P_0 and P_1 i.e. 0 and 13, 26 and 39 Kg P/ha' the response of lime was only upto 1.54 t/ha (half of the lime requirement).

Interaction effects, clearly depicts that if we combine lime with P dose, then certainly, we can reduce the P dose as compared to the without lime.

Table 3. Effect of lime and P on stover yield (q/ha) (1999)

	P_0	P_{13}	P_{26}	P_{39}	Mean
L_0	58.8	68.0	75.4	77.8	70.0
$L_{1/2}$	68.8	75.8	81.6	86.0	78.0
L_1	75.6	79.6	81.0	80.8	79.2
Mean	67.7	74.5	79.3	81.5	
C.D. (P=0.05) L	2.6	P 3.0		PXL	5.3

Table 4. Effect of lime and P on stover yield (q/ha) (2000)

	P_0	P_{13}	P_{26}	P_{39}	Mean
L_0	37.4	44.80	49.20	53.30	46.17
$L_{1/2}$	43.40	49.60	53.2	56.00	50.55
L_1	51.53	55.5	58.8	60.4	56.56
Mean	44.11	49.97	53.73	56.67	
C.D. (P=0.05) L	3.18	P 3.17		PXL	NS

N uptake

A significant increase in N uptake by maize grain during both the years (Figs. 1 and 2) was recorded due to lime application up to highest level of lime i.e. 3.08 t/ha. The significant increase in its uptake was 20 and 32 per cent due to application of 1.54 and 3.08 t/ha over no lime in a respective manner during first year. The corresponding increases in its uptake by grain during second year was 10 and 29 per cent.

Similar to the N uptake in grain, its uptake by maize also increased significantly due addition of lime @ 3.08 over 1.54 t/ha and 1.54 over no lime. The increase was 20 and 49 per cent during 1999 and 32 and 71 per cent during 2000 due to the application of 1.54 and 3.08t/ha over no lime (Fig. 7). The increase in its uptake due to lime application may be due enhancement in yield of grain and straw, more is the yield and more is the uptake. The reduction in soil acidity might have increased the pH and availability of N and ultimately its uptake by the crop (Kihanda *et al.*, 1988).

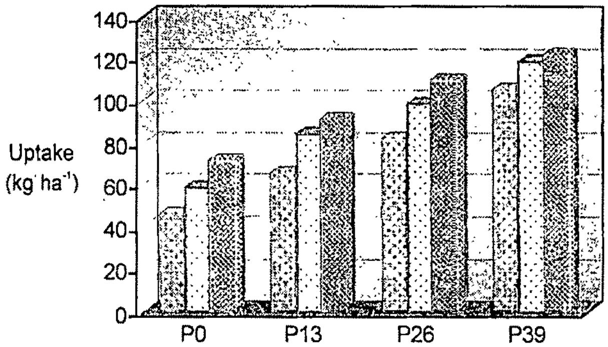
Uptake of N by grain during both the years also increased significantly due to application of P up to 39 kgP/ha. There was increase to the extent of 36, 64 and 95 per cent due to the addition of P @ 13, 26 and 39 kg/ha over on P level. The corresponding increase in its uptake of N by stover due to different levels of P application and highest uptake was in 39 kg/ha level. Percent increase in its uptake was 32, 48 and 62 per cent in 1999 and 41, 52 and 76 per cent in 2000, respectively. Application of P may form the alumino-phosphate complexes with different forms of A1, and thus resulted in lowering of different forms of soil acidity, particularly that of exchangeable acidity (Bache and Crooke, 1981).

A perusal of the Figs. 1 and 2 reveals that application of lime at different levels of P and vice-versa increased the uptake on N by maize garin during both the years; but it was not significant. Uptake of N by straw also varied due to the differently due to lime addition at different levels of P and vice-versa, but in non-significant manner during second year (Fig. 7).

However, the effect of interaction (lime and P) on its uptake was significant during first year. At no lime level, the addition of P up to 39 kg/ha, at 1.54 t/ha up to 26 kg/ha and at 3.08t/ha up to 13 kg/ha, increase in its uptake was recorded. The positive effect of lime was due to 3.08t/ha over control at no P level, in contrast to this the effect of lime reduced to 1.54 t/ha at rest of the levels.

P uptake

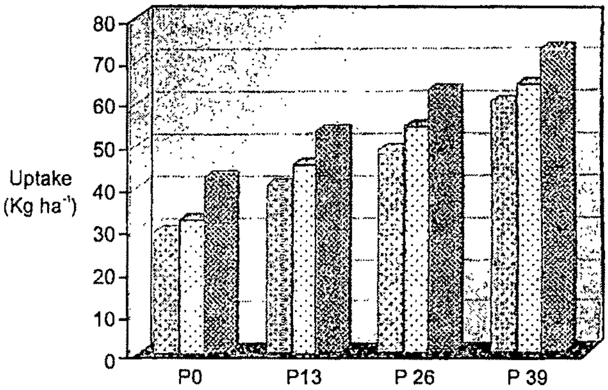
Phosphorus uptake by grain significantly increased up to lime application @ 3.08 t/ha (full lime retirement) during both the years i.e. 1999 and 2000 (Figs. 3 and 4). Similarly, in case of straw, the P uptake increased with increase in lime dose up to full lime requirement during both the years (Fig. 7). The increase over non lime in P uptake by maize grain was to the tune of 68 and 41 per cent during 1999 and 2000 due to lime application @ 3.08 t/ha. Application of lime might have released and retained more P in solution for a longer period than no lime, resulting in higher P sorption (Sharma and Tripathi, 1984). The increase in P uptake due to liming may be due to fact, that it breaks the Fe and Al phosphates in soil, thereby, making P available to plant (Mandal *et al.*, 1975). In addition to this, available P status increased due to increase in mineralization of organic P as affected by lime (Haynes, 1982).



	P0	P13	P26	P39
▢ L0	46.26	65.44	82.17	105.63
▨ L1/2	58.99	84.15	98.79	118.85
▩ L1	71.78	91.39	109.53	121.55

P levels (kg ha^{-1})

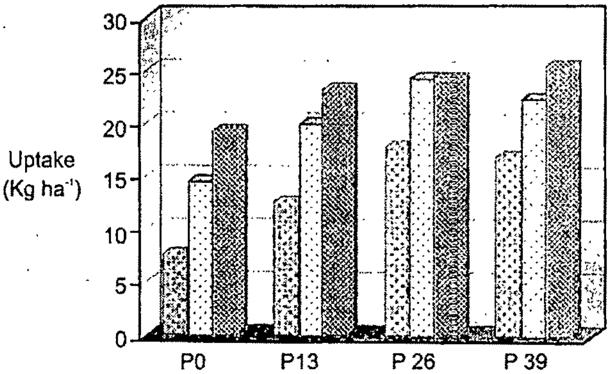
Fig. 1. Effect of P and lime on N uptake by maize grain (1st year)



	P0	P13	P 26	P 39
▢ L0	29.25	40.28	48.63	59.62
▨ L1/2	32.1	45.19	54.12	64.07
▩ L1	42.09	52.98	62.85	72.53

P levels (kg ha^{-1})

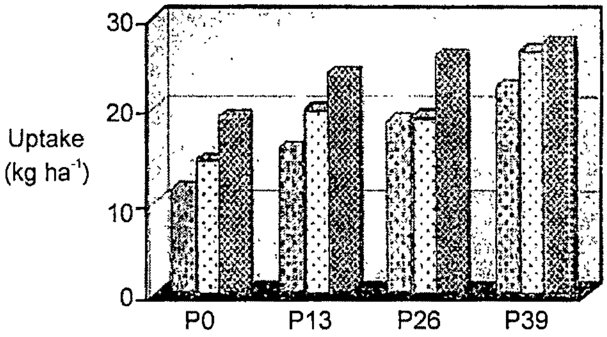
Fig. 2. Effect of P and lime on N uptake by maize grain (2nd year)



	P0	P13	P 26	P 39
▢ L0	7.53	12.58	17.85	16.87
▨ L1/2	14.47	19.99	24.33	22.55
▩ L1	19.15	23.29	24.42	25.57

P levels (kg ha^{-1})

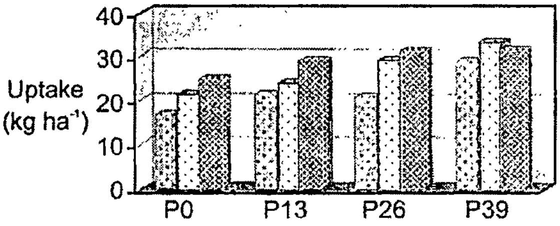
Fig. 3. Effect of P and lime on P uptake by maize grain (1st year)



	P0	P13	P26	P39
▢ L0	11.11	15.69	18.66	22.39
▨ L1/2	14.31	19.82	19.15	26.4
▩ L1	18.99	23.81	25.87	27.16

P levels (kg ha^{-1})

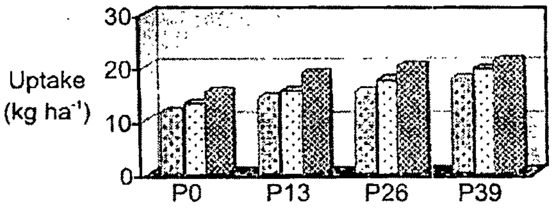
Fig. 4. Effect of P and lime on P uptake by maize grain (2nd year)



	P0	P13	P26	P39
▢ L0	16.46	21.55	20.73	28.9
▨ L1/2	21.56	24.13	29.42	33.64
▩ L1	24.69	29.1	31.27	31.65

P levels (kg ha^{-1})

Fig. 5. Effect of P and lime on K uptake by maize grain (1st year)



	P0	P13	P26	P39
L0	11.49	13.93	15.23	17.47
L1/2	13.04	15.42	17.38	19.38
L1	15.19	18.56	19.97	21.91

P levels (kg ha^{-1})

Fig. 6. Effect of P and lime on K uptake by maize grain (2nd year)

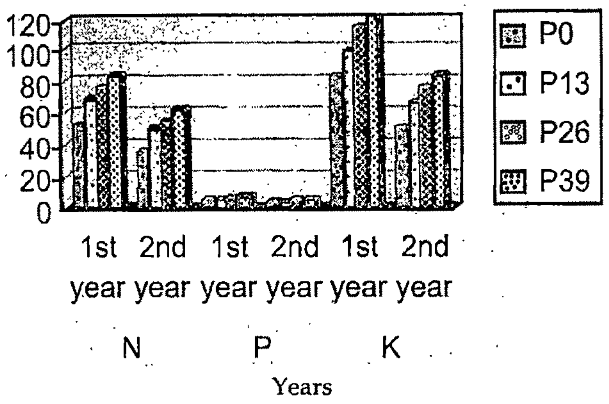


Fig. 7. Effect of P and lime on Uptake of nutrients (kg ha^{-1}) by maize stover

Phosphorus levels up to 26 Kg P/ha during 1999 and up to 39 KgP/ha during 2000 significantly increased the P uptake by maize grain (Fig. 3 and 4). The increase in P uptake by grain was 36, 62 and 58 per cent during first year and 34, 47 and 71 per cent during second year. In case of P uptake by maize straw, during both the years, with each addition of phosphorus, there was significant increase up to higher level during both the years (Fig. 7). The increase in P uptake due to P application is understandable as more of it is added in soil, more it will be taken by plant in P deficient soil (Tagwira, 1995).

Phosphorus uptake by gain as well as straw increased with increase in lime application at different P levels and vice versa, but the effect was non-significant.

K uptake

K uptake by maize grain was found significantly higher in 1.54 t/ha over no lime during both the years. However, it was significantly higher in 3.08 over 1.54 t/ha only in second year (Fig. 5 and 6). There was 27 and 29 per cent increase in its uptake during first year and 12 and 28 per cent during second year due to the addition of lime @ 1.54 and 3.08 t/ha over control. Like grain, in stover, K uptake increased significantly due to lime addition up to full lime requirement dose during both the years. The increase in K uptake over no lime was 11 and 13 per cent during first year and 14 and 27 per cent during second year due to 1.54 and 3.08 t/ha lime application. As the application of lime might have decreased the active forms of Al and soil acidity, this might have led to favorable condition for higher crop yield and K uptake (Verma and Singh, 1996)

Increasing levels of P from 0 to 39 kg/ha, increased the uptake of K by maize grain in significant manner (Fig. 5 and 6). The per cent increase was 19, 38 and 50 during first year and 21, 32 and 45 per cent during second year due to the application of 13, 26 and 39 kg/ha, respectively. In case of P effect, significant improvement in K uptake by stover was recorded up to highest lelvel i.e. 39 Kg P/ha. The increase over was no P, was 20, 38 and 43 per cent during 1999 and 32, 51 and 65 per cent during 2000. respectively. The increase in K putake by the crop due to P, may be owing to higher yield.

These findings confirmed are by the similar results by Jama *et al.* (1997). The interraction effect of lime and P on K uptake by grain and stover was not significant.

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PHYTOTOXICITY OF PENDIMETHALIN IN MUSTARD AND EFFECT OF WEED CONTROL ON PLANT NUTRIENTS' CONSERVATION IN SOIL

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ABSTRACT

Results obtained in the experiment showed that pendimethalin had higher weed control efficiency than fluchloralin, however, pendimethalin became phytotoxic to mustard and non-selective in action at all the doses. Among the herbicides fluchloralin 1.25 kg a.i. ha^{-1} registered highest seed yield of mustard (10.39 q. ha^{-1}) as it controlled the weeds like *Polygonum percsicaria, Polygonum pensylvanicum, Polygonum orientale* and *Stellaria midia* effectively. However, black necrotic symptom at the base of the plant was observed during siliqua development stage, which disappeared at later part of crop growth. Weeds removed huge amount of plant nutrients from soil to the tune of 165.13 kg N, 22.54 kg P and 158.84 kg K ha^{-1}. Fluchloralin at 1.00 kg a.i. ha^{-1} was effective as preemergence herbicide in mustard to control weeds and to conserve the plant nutrients in soil on account of 118.08 kg N, 15.56 kg P and 104.58 kg K ha^{-1}.

Key words : Mustard, nutrient removal, pendimenthalin, fluchloralin, phytotoxicity, pre-emenrgence herbicide.

Rapeseed and mustard is a major oil seed crop in West Bengal, however, the productivity of this crop in West Bengal is still far behind than that the leading oil seed producing states of India. One of the major causes of low oil seed productivity is high weed pressure in mustard. The weed problem is severe in northern parts of West Bengal due to heavy rainfall and deficiencies of micronutrients in soil leading to aggressive growth of weeds with high invasive potential. The poor farmers demographically dominated in this region could not effort for manual weeding to minimize weed pressure and thus it becomes a constraint in mustard cultivation. Weed tends to limit growth of crop plant through competition for growth factors. Among the growth factors competition for plant nutrients comprises an important aspect in weed-crop competition. Weeds possess the ability to produce huge dry matter leading to undue removal of plant nutrients from soil. Negative correlations was conserved between weed dry matters produced during 30,60 DAS and at harvest and dry matter of mustard plants and also between N removal by weeds and mustard plants (Dashora *et al.*, 1990). So far no research activity has been conducted in these areas to generate information on chemical method of weed control. In view of these facts the present study was, therefore, undertaken with the objective to evaluate bio-efficacy of preemergence herbicides like pendimethalin and fluchloralin in mustard to control the weeds appeared in terai agro-climatic region of West Bengal and to estimate the nutrients removed by weeds and their conservation in soil through weed control.

MATERIALS AND METHODS

A field experiment was conducted om the farm of U.B.K.V. during the rabi seasons of 2002 and 2003. The soil was sandy loam with pH 5.8. The experiment was laid out in randomized complete block design with three replications. Ten treatments comprising four doses of pendimethalin (0.75 kg a.i. ha^{-1}, 1.00 kg a.i. ha^{-1}, 1.25 kg a.i. ha^{-1}, 1.50 kg a.i. ha^{-1}) and three doses of fluchloralin (1.00 kg a.i. ha^{-1}, 1.25 kg a.i. ha^{-1}, 1.50 kg a.i. ha^{-1}) were tested along with two hand weedings at 20 DAS and 40 DAS, weedy check and complete weed free situation.

Weed samples were taken from each plot at 15 days interval after sowing with the use of quadrant having the size if 0.5 x 0.5 m^2. N, P and K concentration of the weeds collected at 15 days interval were analyzed at laboratory and removal of plant nutrients by the weeds were measured with the help of dry matter weight and per cent nutrient concentration of the weeds. The per cent growth reduction of the crop plants treated with different doses of herbicide was determined by comparing them with healthy plants raised without herbicide treatment at 12 days after sowing. Herbicides pendimethalin and fluchloralin were applied as pre-emergence treatment with high volume sprayer 550 L ha^{-1}. Mustard cv. B9 was sown on December 19, 2002 and November 17, 2003. Recommended package of practices other than weed control was adopted to grow the experimental crop.

RESULTS AND DISCUSSION

Effect on weeds

Polygonum persicaria, P. pensylvanicum, P. orientale, Stellaria media and *Vicia sativa* were the major weeds in the experimental field. The other weeds observed in the experiment were *Cynodon dactylon* and *Setaria glauca*. Among the herbicides the weed control efficiency of pendimethalin 1.50 kg a.i. ha^{-1} showed highest weed control efficiency throughout the crop growth (Table 1). Fluchloralin also had good weed control efficiency. At 90 DAS the values of weed control efficiency in fluchloralin 1.25 kg a.i. ha^{-1} (63.32%) and 1.50 kg a.i. ha^{-1} (65.54%) were higher than the treatment with two hand weeding at 20 and 40 DAS (58.4%). Weed control efficiency during second year of experimentation was slightly higher than first year as late sown mustard was exposed to comparatively high weed pressure dominated by different species of *Polygonum*. Hand weeding employed at 20 and 40 DAS failed to minimize the weed growth to rapid emergence and establishment of *Polygonum* after hand weeding and thus resulting in poor weed control efficiency at later part of crop growth (Table 1).

Phytotoxicity on crop

There was variation on percent growth reduction of the crops in different herbicidal treatments. All the pendimethalin treatments showed phytotoxic effect on mustard plants and lowest dose of pendimethalin 0.75 kg a.i. ha^{-1} caused the growth reduction on account of 66.97%. Fluchloralin 1.50 kg a.i. ha^{-1} became phytotoxic in limited extent and caused the growth reduction to the tune of 36.99 % (Table 1). Fluchloralin at 1.00 kg a.i. ha^{-1} was non-phytotoxic to mustard and initial growth suppression of 20.93 % was recovered completely at the later part of the crop growth. Light textured sandy loam soil and adequate soil moisture prevailed at the experimental site during pre-emergence treatment of herbicide led to the movement of herbicide at seeding zone and consequently failed to ensure the operation of depth protection mechanism in conferring selectivity of herbicide. This resulted in phytotoxicity to the mustard in case of pendimathalin at all the doses and fluchloralin at 1.50 kg a.i. ha^{-1}. Black necrotic symptom at the base of the plant was observed during siliqua development stage in the treatment comprising fluchloralin 1.25 kg a.i. ha^{-1}. However, this symptom disappeared at later part of crop growth without causing mortality of the plant.

Effect on Plant population

Among the treatments fluchloralin 1.25 kg a.i. ha^{-1} registered highest plant population (35.8 plants m^{-2}), which was closely followed by the treatment fluchloralin 1.0 kg a.i. ha^{-1} having no significant difference among each other (Table 1). The lowest plant population was recorded in the treatment pendimethalin 1.5 kg a.i. ha^{-1} (1.65 plants m^{-2}), which was even lower than the values recorded in weedy plot (4.55 plants m^{-2}). Thhis was mainly due to phytotoxicity of pendimethalin on mustard resulting in mortality of plant. Fluchloralin 1.50 kg ha^{-1} also caused phytotoxicity, however, degree of phytotoxicity was lower than pendimethalin. If the weeds were left uncontrolled, therefore, 93.65% reduction in crop stand took place compared to complete weed-free situation.

Effect on weed index

High value of weed control efficiency corresponding to high value of weed index in pendimethalin at all the doses attributed its non-selective action and became ineffective as a pre-

Table 1. Effect of treatments on phytotoxicity on crop, plant population, yield attributing characters, seed yield and weed index

Treatment	Crop injury (% Growth	Plant population (plant m^{-2})		Siliqua plant^{-1}		Seed siliqua^{-1}		Seed yield (q ha^{-1})		Weed control efficiency at 90 DAS		Weed index (%)	
		2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Pendimethalin 0.75 kg a.i. ha^{-1}	66.97	9.50	10.68	65.67	67.33	9.67	9.67	2.80	3.13	64.50	66.12	74.22	75.66
Pendimethalin 1.00 kg a.i. ha^{-1}	79.79	7.63	8.48	63.67	64.67	9.00	9.33	2.23	2.46	71.33	73.78	79.47	80.86
Pendimethalin 1.25 kg a.i. ha^{-1}	85.79	5.41	6.22	57.67	58.67	8.33	8.67	1.62	1.86	76.68	79.35	85.08	85.57
Pendimethalin 1.50 kg a.i. ha^{-1}	93.70	1.30	2.00	48.33	46.00	7.33	7.33	0.24	0.39	79.78	82.49	97.79	96.97
Fluchloralin 1.00 kg a.i. ha^{-1}	20.93	30.53	36.59	71.33	72.33	9.33	9.67	8.90	10.67	57.78	58.46	18.05	17.16
Fluchloralin 1.25 kg a.i. ha^{-1}	24.98	31.59	40.00	72.67	72.67	9.67	9.67	9.16	11.61	62.88	63.75	15.6	09.86
Fluchloralin 1.50 kg a.i. ha^{-1}	36.99	23.64	26.26	69.67	71.67	9.33	9.33	6.31	6.93	65.06	66.02	40.98	44.80
HW at 20 and 30 DAS	-	25.93	28.82	61.67	62.67	9.33	9.33	6.41	7.11	58.15	58.65	41.90	46.21
Weedy check	-	4.49	4.59	47.67	47.33	7.33	8.33	0.77	0.72	-	-	92.91	94.37
Weed-free	-	36.92	44.30	71.00	71.33	9.67	9.67	10.86	12.88	100.00	100.00	-	-
SEm (±)	-	0.74	0.85	1.20	1.20	0.40	0.33	1.53	2.11	0.57	0.64	-	-
C.D. at 5%		1.55	1.78	2.53	2.52	0.83	0.75	3.21	4.44	1.20	1.34	-	-

HW-Hand weeding. DAS-Day after sowing

Table 2. Effect of treatment on total nutrients (kg ha^{-1}) by weeds and conservarion of plant nutrients in soil through weed control

	Total plant nutrient removal by weeds (Polygonum and other weeds) in kg ha^{-1}						Conservation of plant nutrient in soil through weed control in kg ha^{-1}					
	Nitrogen removal		Phosphorus removal		Potassium removal		Nitrogen conservation		Phosphorus conservation		Potassium conservation	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Pendimethalin 0.75 kg a.i. ha^{-1}	49.91	43.03	7.46	6.01	48.35	44.70	120.23	117.08	15.74	15.87	115.19	109.43
Pendimethalin 1.00 kg a.i. ha^{-1}	41.45	33.83	5.99	5.01	41.41	34.69	128.69	126.28	17.21	16.87	122.13	119.44
Pendimethalin 1.25 kg a.i. ha^{-1}	31.7	26.90	4.66	4.00	32.56	27.75	138.44	133.21	18.54	17.88	130.98	126.38
Pendimethalin 1.25 kg a.i. ha^{-1}	25.74	21.55	4.07	3.43	27.23	20.18	144.40	138.56	19.13	18.45	136.31	133.95
Fluchloralin 1.00 kg a.i. ha^{-1}	50.27	43.82	7.41	6.55	51.75	45.95	119.87	116.29	15.79	15.33	111.79	108.18
Fluchloralin 1.25 kg a.i. ha^{-1}	45.25	39.33	6.69	5.92	46.32	14.00	124.89	120.78	16.51	15.96	117.22	113.13
Fluchloralin 1.50 kg a.i. ha^{-1}	38.08	34.60	5.94	5.32	40.74	36.76	132.06	125.51	17.26	16.56	122.80	117.37
Weed-free	52.13	51.72	9.81	7.76	55.10	53.42	118.01	108.39	13.39	14.12	108.44	100.70
Weedy check	170.14	160.11	23.2	21.88	163.54	154.13						

Table 3. Economics of mustard cultivation as influenced by treatments

	General cost of cultivation (Rs ha^{-1})		Cost of tretments (Rs ha^{-1})		Total cost of cultivation (Rs ha^{-1})		Gross income (Rs ha^{-1})		Net income (Rs ha^{-1})		Benefit : Cost ratio	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Pendimethalin 0.75 kg a.i. ha^{-1}	7959	7959	1920	1920	09879	03879	5750	6440	-4129	-3239	0.58	0.65
Pendimethalin 00 kg a.i. ha^{-1}	7959	7959	2420	2420	10379	10379	4585	5055	-5794	-5324	0.44	0.49
Pendimethalin 1.25 kg a.i. ha^{-1}	7959	7959	2920	2920	10879	10879	3340	3840	-7539	-7039	0.31	0.35
Pendimethalin 1.25 kg a.i. ha^{-1}	7959	7959	3420	3420	11379	11379	510	835	-10869	-10554	0.04	0.07
Fluchloralin 1.00 kg a.i. ha^{-1}	7959	7959	1531	1531	09490	09490	18550	22135	9060	12645	1.95	2.33
Fluchloralin 1.25 kg a.i. ha^{-1}	7959	7959	1809	1809	09768	09768	19090	24030	9322	14262	1.95	2.46
Fluchloralin 1.50 kg a.i. ha^{-1}	7959	7959	2087	2087	10046	10046	13270	14560	3224	4514	1.32	1.45
HW at 20 and 30 DAS	7959	7959	2700	2700	10659	10659	13490	14930	2831	4271	1.27	1.40
Weed-cheek	7959	7959	-	-	07959	07959	1630	1525	-6329	-6434	0.21	0.19
Weedy-free	7959	7959	5400	5400	13359	13359	22520	26610	9161	13251	1.69	1.99

HW-Hand weeding, DAS-Days after sowing

emergence herbicide to control weeds in mustard. Fluchloralin at 1.25 and 1.00 kg a.i. ha^{-1} registered high value of weed control efficiency as well as low value of weed index (Table 1). Fluchloralin with these doses proved to become effective as selective pre-emergence herbicide in order to control weeds in mustard without causing phytotoxicity on mustard plant.

Effect on yield attributes and yield

Fluchloralin 1.25 kg ha^{-1} showed highest number of siliqua plant^{-1} (72.67) closely followed by fluchloralin 1.00 kg a.i. ha^{-1} (71.83) without any significant difference. The lowest number of siliqua plant^{-1} was found in weedy plot. Number of seeds siliqua^{-1} was highest (9.67) in pendimethalin 0.75 kg a.i. ha^{-1} and fluchloralin 1.00 and 1.25 kg a.i. ha^{-1}, which was statistically at par with weed-free situation. Among the herbicidal treatments pendimethalin 1.50 kg a.i. ha^{-1} registered lowest number of seeds siliqua^{-1} (7.33). Highest seed yield of mustard was obtained in completely weed-free plot (11.87 q ha^{-1}), which was statistically similar with the treatments fluchloralin 1.25 (10.39 q ha^{-1}) and 1.00 kg a.i. ha^{-1} (9.79 q ha^{-1}). The lowest weed yield was obtained in pendimethalin 1.5 kg a.i. ha^{-1} (0.32 q ha^{-1}) closely followed by weedy check and the herbicidal treatments pendimethalin 1.25, 1.00 and 0.75 kg a.i. ha^{-1} without having any significant difference (Table 1).

Plant nutrient removal by weeds

Results obtained on total plant nutrient removal by weeds during crop growth were determined by relating the concentration of nutrients in weeds with the dry matter of weeds found in each treatment. The results of nutrient removal obtained from the experiment revealed that the weeds removed huge amount of nitrogen and the value estimated was 165.125 kg N ha^{-1} (Table 2). Adoption of weed control measures through chemical and manual method restricted the removal of nitrogen to the tune of 70% in case of fluchloralin 1.0 kg a.i. ha^{-1} to 85% in case of pendimethalin 1.5 kg a.i. ha^{-1} through weed control. In addition to nitrogen removal, weeds also removed considerable amount of phosphorus and potassium on account of 22.54 kg ha^{-1} and 158.84 kg ha^{-1}, respectively (Table 2).

Implication of weed control measures minimized P and K removal to the tune of 68% to 82% in case of fluchloralin 1.0 kg a.i. ha^{-1} and pendimethalin 1.5 kg a.i. ha^{-1}, respectively.

Conservation of plant nutrient in soil through weed control

Effectiveness of fluchloralin at the dose of 1.0 kg a.i./ha in terms of selective action on weeds without causing phytotoxicity on mustard plant resulted in conservation of plant nutrients on account of 118.08 kg N ha^{-1}, 15.56 kg P ha^{-1} and 109.99 kg K ha^{-1} (Table 2). Conservation of plant nutrients in soil was highest in the treatment pendimethalin 1.5 kg a.i. ha^{-1} with the value of 141.48 kg N ha^{-1}, 18.79 kg P ha^{-1} and 135.13 kg K ha^{-1}, however, this treatment became non-selective in action and was found ineffective as preemergence treatment in mustard. Hand weeding at 20 and 40 DAS registered lowest amount of conserved plant nutrients in soil with the value of 113.2 Kg N ha^{-1}, 14.03 Kg P ha^{-1} and 104.58 K ha^{-1} (Table 2).

Economics of the system

Among the weed control treatments the highest gross income was obtained under fluchloralin 1.25 kg a.i. ha^{-1} (Rs. 19090 ha^{-1}). (Table 3). The net rutern having negative value was obtained in all the treatments of pendimethalin. Benefit cost ratio was highest in fluchloralin 1.25 kg a.i. ha^{-1} (2.21) followed by the treatment fluchloralin 1.0 kg a.i. ha^{-1} (2.14). Lowest benefit cost ratio was found in pendimethalin 1.5 kg a.i. ha^{-1} (0.06) (Table 3).

Phytotoxicity of the pendimethalin on mustard at all the doses made this herbicide non-selective in controlling weeds. Fluchlorlin at 1.25 kg ha^{-1} registered highest seed yield, however, black necrotic symptom at the base of the plant was observed during siliqua development stage, which disappeared at later part of crop growth. Therefore, fluchloralin at 1.00 kg ha^{-1} became effective as selective pre-emergence herbicide in mustard in minimizing risky proposition relating to phytotoxicity in mustard due to herbicide application and was comparatively safe to be adopted as chemical method of weed control. Pal *et al.* (2000) also found that pre-emergence application of fluchloralin at 1.00 kg ha^{-1} was more effective in minimizing the weed pressure in Indian mustard fields compared to the same doses of pendimathalin in southern parts of West Bengal. Anand *et al.* (2000) also reported the similar findings.

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EFFECT OF WEATHER ON MUSTARD DYNAMICS UNDER SEMI-ARID ENVIRONMENT

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ABSTRACT

Field experiments were carried out on sandy loam soil of Indian Agricultural Research Institure (New Delhi) farm area with mustard cultivars Pusa Jaikisan and Varuna which were grown for two consecutive rabi seasons (2000-2001 and 2002-2003) at ten different dates following recommended agronomic practices. Irrespective of sowing dates and crop season LAI, CGR, PGR, total biomass and seed yield were higher in Pusa Jaikisan than in Varuna. Values of crop growth parameters and seed yield were maximum when crop was sown between 15th and 29th October in both the cultivars and seasons which might be due to crop sown in this period were exposed to the optimum thermal environment for growth and development. The value of LAI, total biomass production, CGR and PGR were higher in first crop season than the second crop season in all sowing dates in both the cultivars. A significant reduction of seed yield both in Pusa Jaikisan and Varuna in second season was probably due to prevailing cold spell coupled with low bright sunshine hours during the month of January and February, 2003 that might have caused reduction in LAI, CGR, PGR and biomass production resulting lower seed yield.

Key words : Mustard, leaf area index, crop growth rate, pod growth rate, temperatures, and bright sunshine hours.

Weather plays an important role in growth, development and yield of mustard, an important oilseed crop in India. The rate of crop growth and development is a function of the energy receipt and temperature conditions in the crop-growing season. (Mendham and Slisbury, 1995; Robertson *et al.*, 2002). Some efforts were made (Kumari *et al.*, 1994; Nanda *et al.*, 2000; Singh *et al.*, 2000; Kar and Chakravarty, 2000; Kar and Chakravarty, 2001) relating crop growth and seed yield in mustard with prevailing weather conditions. Nanda *et al.*, (1994) reported that leaf appearance and leaf expansion rate were higher at higher temperatures (20°C) than at the lower temperatures (13°C). Working with field grown *Brassica* species Singh *et al.*, (2000) observed that a sudden rise in temperatures (from 25.6 to 35.4) particularly during pod growth period, followed by a sharp increase (32.4 to 41.5°C) during maturity under delayed sown conditions resulted in a significant reduction of biomass accumulation and its partitioning to various parts. The seed yield in mustard is positively and significantly associated with biomass production, crop growth rate and pod growth rate (Chauhan and Bhargava, 1984). Rao (1992) reported that the seed yield of mustard reduced significantly in warmer season than in the cooler season because of decrease in the radiation regime due to cloudy skies associated with passage of 'Western Disturbances' in Delhi region. Thus the bright sunshine hours play an important role in crop growth and seed yield in this crop. In present investigation an attempt has been made to study the effect of variation of weather parameters namely temperature and bright sunshine hours on the growth and seed yield of this important oilseed crop.

MATERIALS AND METHODS

Two mustard cultivars namely, Pusa Jaikisan and Varuna were sown during rabi season 2001-2002 and 2002-2003 at weekly intervals on ten dates starting from 1st October to 3rd December on the sandy loam soils of research farm of Indian Agricultural Research Institute, New Delhi (28°35'N, 77°10'E and 288.7 m AMSL) having semi arid environment. The experiment was conducted in randomized block design and the crop was grown following recommended agronomic practices. Three continuous plants from a row in each plot were collected for assessing the leaf area index (LAI) and biomass production at weekly interval. Green leaves from the samples were separated and the area of the leaves was measured using leaf area meter (LI-3100). Weekly LAI, crop growth rates (CGR) and Pod growth rates (PGR) were computed following Kumar *et al.* (1999) and Kar and Chakravarty (2000). For seed yield, samples were collected randomly from one square meter area from each plot at two places. Data on maximum temperature, minimum temperature, rainfall and bright sunshine hours for both the crop growing seasons were taken from the records of the adjoining Agrometeorological observatory of IARI and presented in Fig. la.

RESULTS AND DISCUSSION

Leaf area index

The LAI was relatively higher in Pusa Jaikisan than in Varuna in all sowing and both the seasons (Fig. 2). In both the cultivars peak value LAI was higher in the crop sown on 29th October (Pusa Jaikisan-5.75 & Varuna-5.4) in the first and second crop season, respectively. As can be expected, the peak LAI drastically reduced with the delay in sowing from 29th October in both the cultivars and the season. In case of late sown crops (beyond 29th October), initial crop growth stages were exposed to relatively low temperatures, which might have caused reduction of leaf expansion rate and leaf area. On the other hand, early growth stages of early sown crops (before 15th October) were exposed to high temperatures prevailed which might have accelerated the vegetative growth and forced the crop enter into pod development stage much earlier, resulting in marginal reduction in LAI. It can be inferred that if these two varieties were sown between 15th October and 29th October, the LAI could be optimum and as the sowing delayed the LAI would be reduced. In late sown conditions the reduction could be appreciable and it could be as high as 2.45 (5.3 in the crop sown on 29th October to 2.85 in the crop sown on 3rd December).

The LAI values in both the cultivars were in first season as compared to the second season in all sowing dates. It was observed that there was a sudden drop in maximum and minimum temperatures during January and February, 2003 in second crop season particularly in the first fortnight of January when differences of daily maximum and minimum temperatures were as high as 13.5°C and 13°C, respectively (Fig. 1b). Similarly bright sunshine hours below 2 hour (except few occasions) during January and Ferbuary 2003 continuously, whereas, the crop sown on first season were exposed to more number of sunshine hours ranging from 4 to 8 hours in these two months and also throughout the season. The various growth stages of the crop sown on different dates in second season were exposed to adverse climatic conditions. Thus low temperatures coupled with the low bright sunshine hours in the second season probably reduced the rate of photosynthesis and leaf expansion rates leading to reduction in LAI.

Total biomass production

Like LAI, the above ground biomass production at maturity was relatively higher in Pusa Jaikisan than in Varuna in all sowings and both the seasons (Table 1). In both the cultivars biomass production was maximum in the crop sown on 29th October (Pusa Jaikisan - 1461 & Varuna - 1361 g/m^2) and 22nd October (Pusa Jaikisan-1267 & Varuna-1235 g/m^2) in the first and second crop season, respectively. In both the seasons, the total biomass production at maturity increased gradually in the crops sown from 1st to 29th October and decreased rapidly from 5th November onwards. The relatively short vegetative period induced by high temperature in case of late sown crops might have reduced the LAI and thus biomass production. Thus, it is evident that if these two varieties were sown between 15th October and 29th October, the biomass production would be optimum.

Total biomass production of the crops grown on second season was significantly low as compared to that in the first season. Lower biomass production in both the cultivars in second season as compared to first season, might be due to occurrence of cold spell for longer period

(January & February, 2003) coupled with low average sunshine hours (2.1/ day). In the second season, prevailing low temperature and low sunshine hours during vegetative growth of the late sown crops (beyond 29th October) and pod development stage of the crops sown before 29th October adversely affected the growth the crop and reduced total biomass production.

Crop growth rates (CGR)

The CGRs in both the cultivars were significantly affected by both sowing dates as well as seasons (Fig. 3). The value of CGR was found to be marginally higher in Pusa Jaikisan than in Varuna in both the seasons and in all sowing, which might be due to higher leaf area index and biomass in this cultivar. The peak CGR varied from 12.2 to 26.6 g/m^2/day in Pusa Jaikisan, where as in Varuna, the peak CGR varied from 10.5 to 25.3 g/m^2/day in various sowings and crop seasons. The peak CGR attained at 80 to 100 day after sowing in both the cultivars and the season in the plants sown on different dates. It was observed that the peak CGR in both the cultivars and the seasons was maximum in the plants sown from 15th to 29th October. Reduction of peak CGR was considerably higher in late sown crops (beyond 29th October), which might be due to decrease in LAI and biomass production caused by increase in maximum and minimum temperatures during the pod growth stage of the late sown crops.

The value of CGR was marginally higher in the first season (21.4 g/m^2/day in Pusa Jaikisan and 19.5 g/m^2/day in Varuna) than in the second (19.5 g/m^2/day in Pusa Jaikisan and 17.3 g/m^2/day in Varuna). Relatively lower maximum and minimum temperatures coupled with lower average sunshine hours during second crop season might have caused reduction in crop growth and hence the CGR. The CGR values observed in the present study were within the range as reported by Kar and Chakravarty (2001).

Pod growth rates (PGR)

In all the sowings and cultivars, the peak PGR was found to occur from 100 to 130 days after sowings in both the seasons and was marginally higher in Pusa Jaikisan (15.8 g/m^2/day) than in Varuna (14.3 g/m^2/day), which could be attributed to the relatively higher leaf area index, biomass production and CGR in Pusa Jaikisan. It was observed that in both the cultivars and the seasons, the peak PGR was considerably higher in the plants sown from 15th to 29th October and the peak was maintained for longer period as compared to the late sown crops (beyond 29th October). It is interesting to observe that the peak value of PGR was maximum in the crops sown on 5th and 12th November, in both the seasons and cultivars, but the peak was maintained for relatively shorter period as compared to the early sown on 1st and 8th October), the peak PGR was found to be

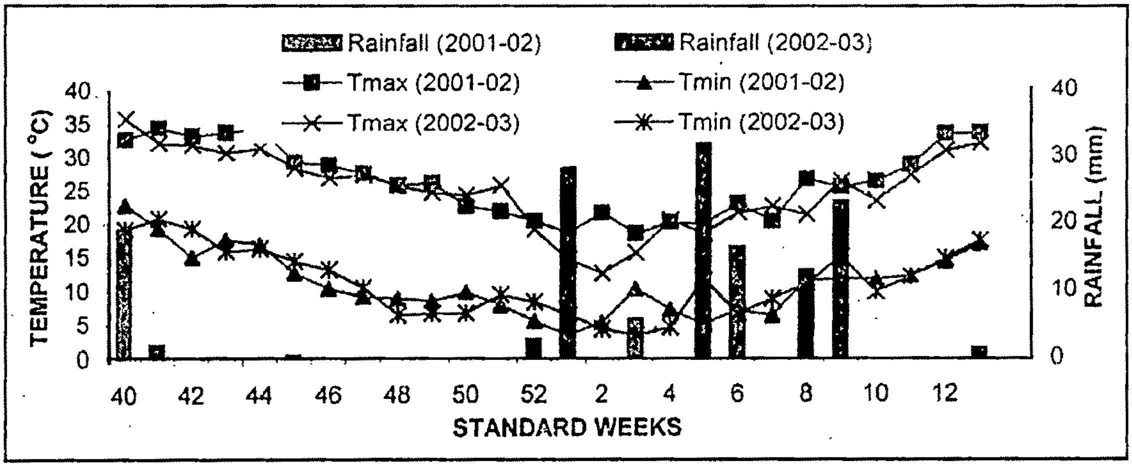

Fig. 1a. Mean daily variation of maximum, minimum temperatures and total weekly rainfall and mean daily variation sunshine hours

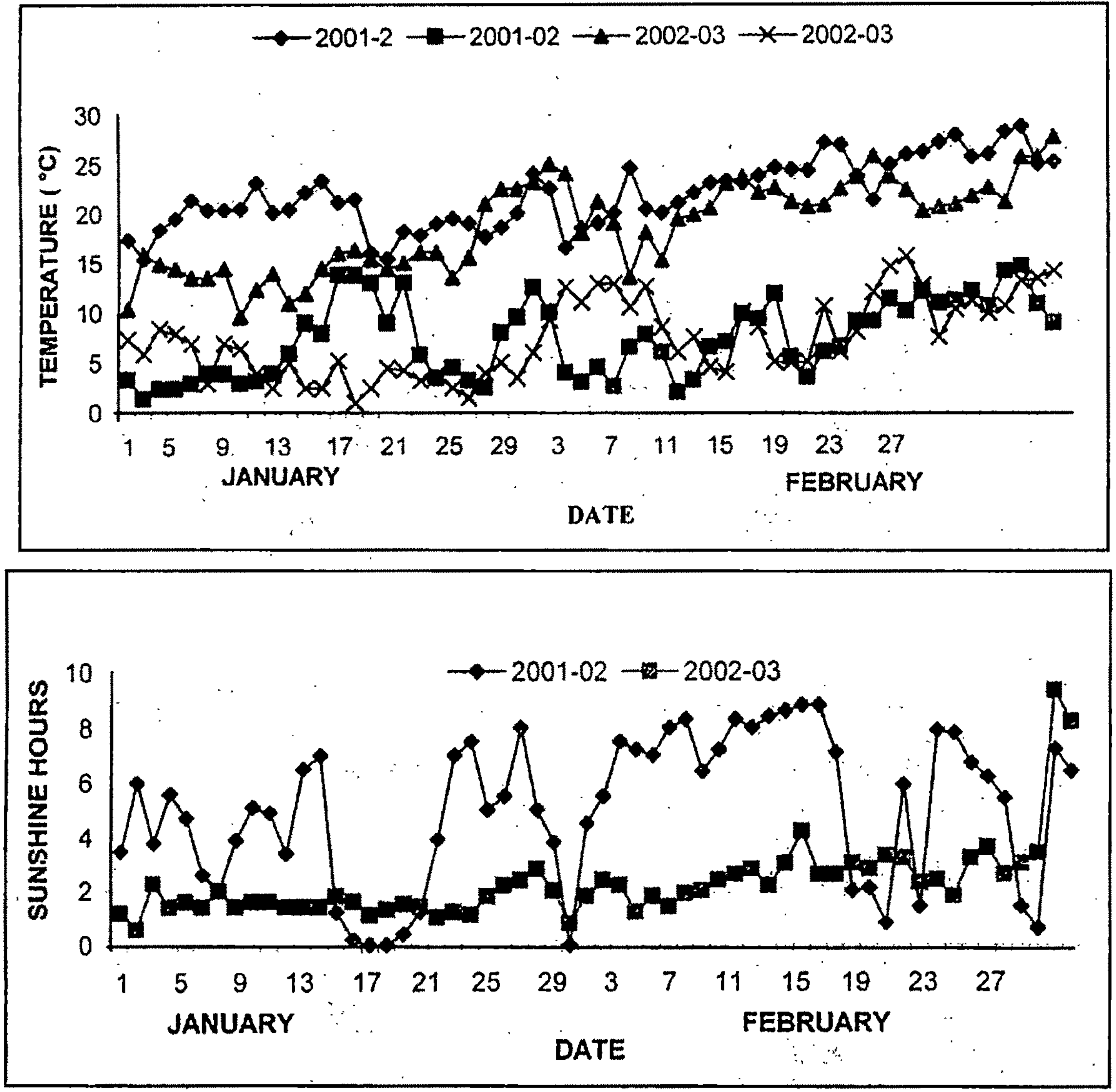

Fig. 1b. Comparison of maximum and minimum temperatures and bright sunshine hours during January and February 2002 and 2003

minimum but the level was maintained for relatively longer period as compared the crops sown on other dates.. In early sown crops, the pod growth period was exposed to relatively lower maximum and minimum temperatures, where as in case of late swoon crops, this prodded was exposed to the gradually increasing temperature in the later part of the crop growth seasons. Thus, it can be inferred that the crops sown between 15th and 29th October which were exposed to the optimum thermal environment for pod growth and development in both the cultivars, resulting in the higher growth rates.

The PGR was considerably higher in the first season (18.3 g/m^2/day in Pusa Jaikisan and 15.6 g/m^2/day in Varuna) as compared to the second season (13.3 g/m2/day in Pusa Jaikisan and 12.9 g/m^2/day in Varuna). Prevailing lower day and night temperatures coupled season might have caused reduction in leaf area index, biomass production and ultimately the pod growth rate in both the cultivars.

Seed yield

During first crop season the seed yield in Pusa Jaikisan varied from 8.2 to 29.6 while in the Varuna, the seed yields were slightly less (7.9 to

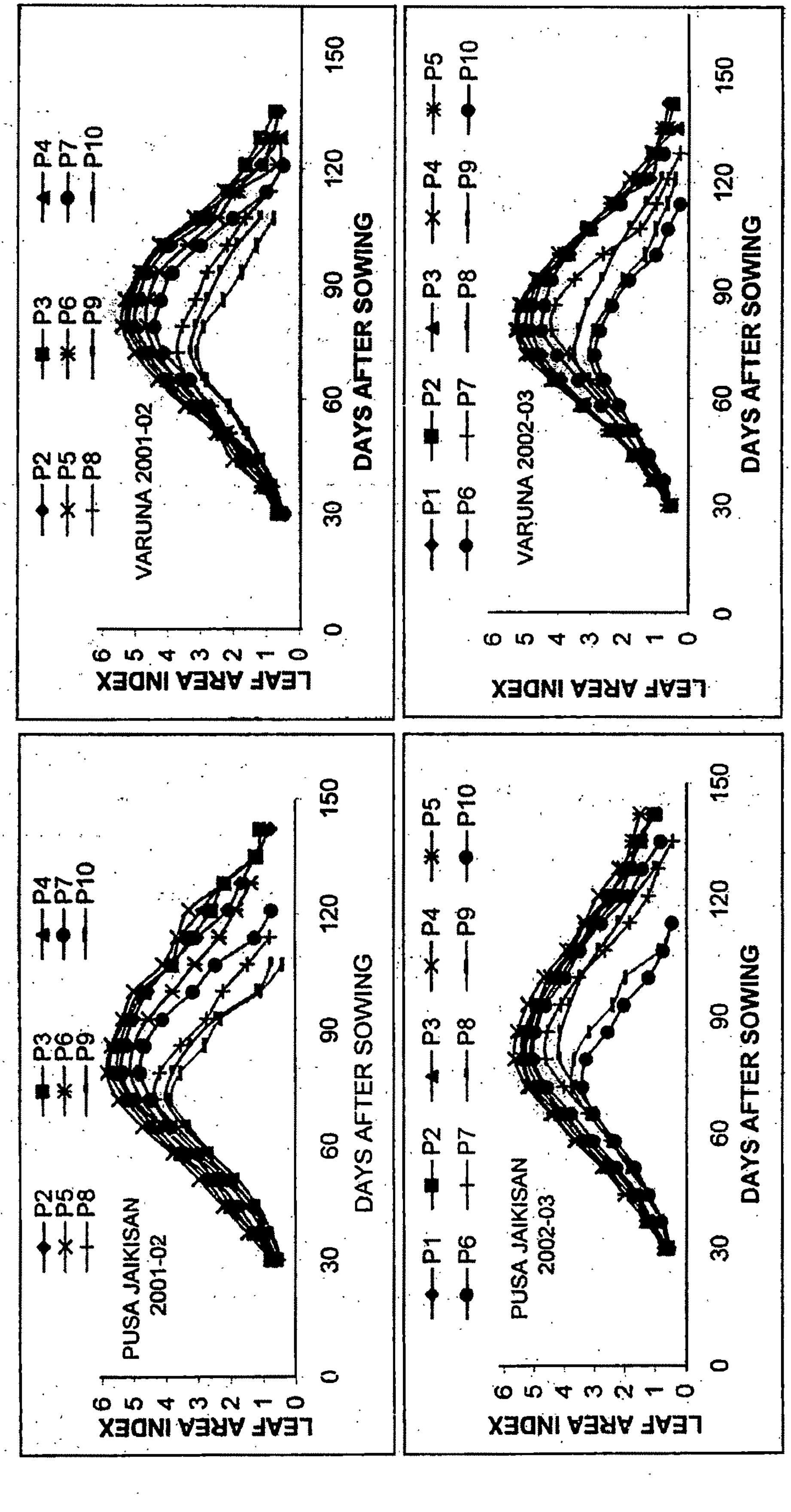

Fig. 2. Leaf area index in Pusa jaikisan and Varuna during rabi 2001-02 and 2002-03

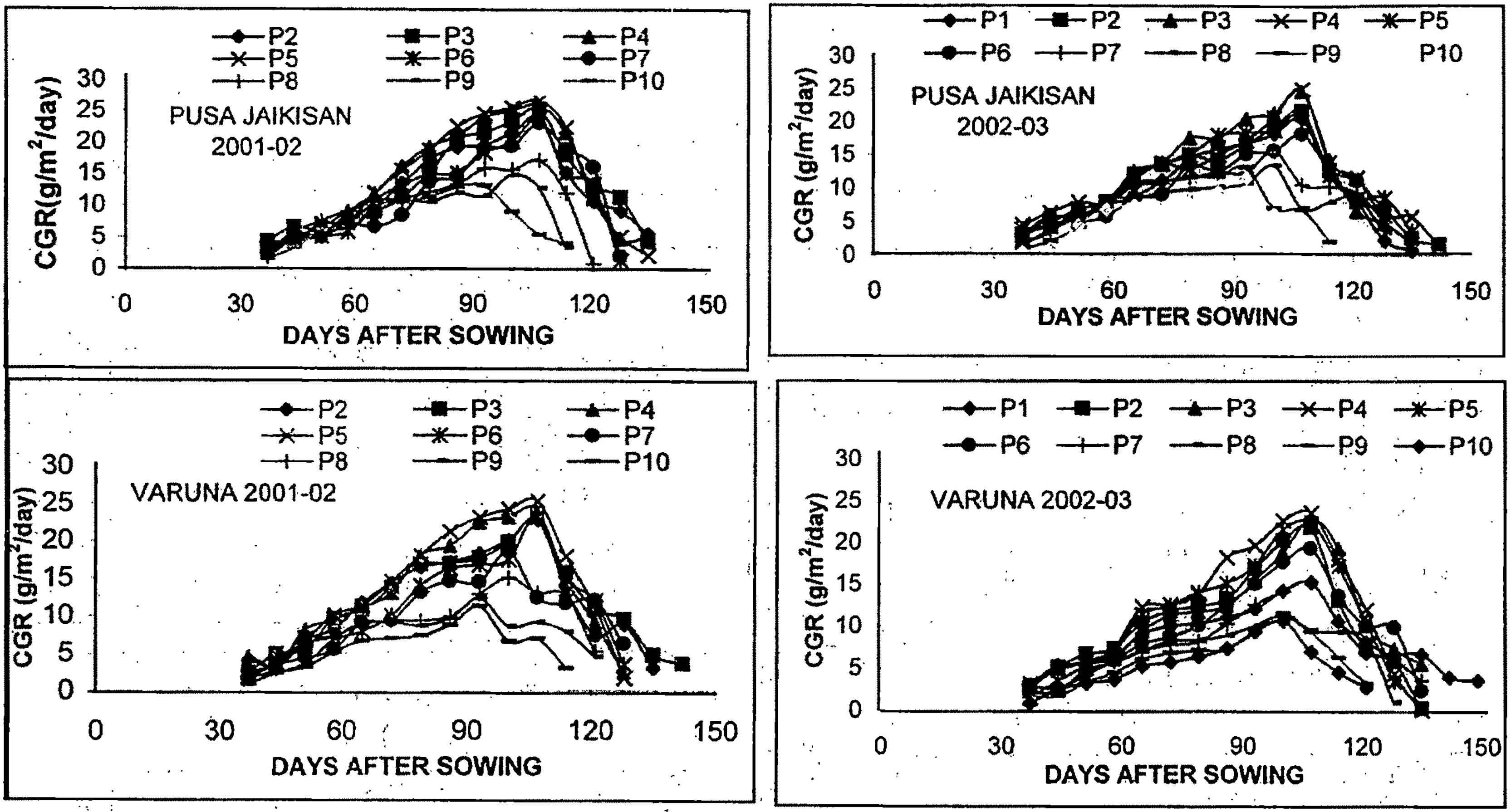

Fig. 3. Crop growth rate (CGR) in Pusa jaikisan and Varuna during rabi 2001-02 and 2002-03

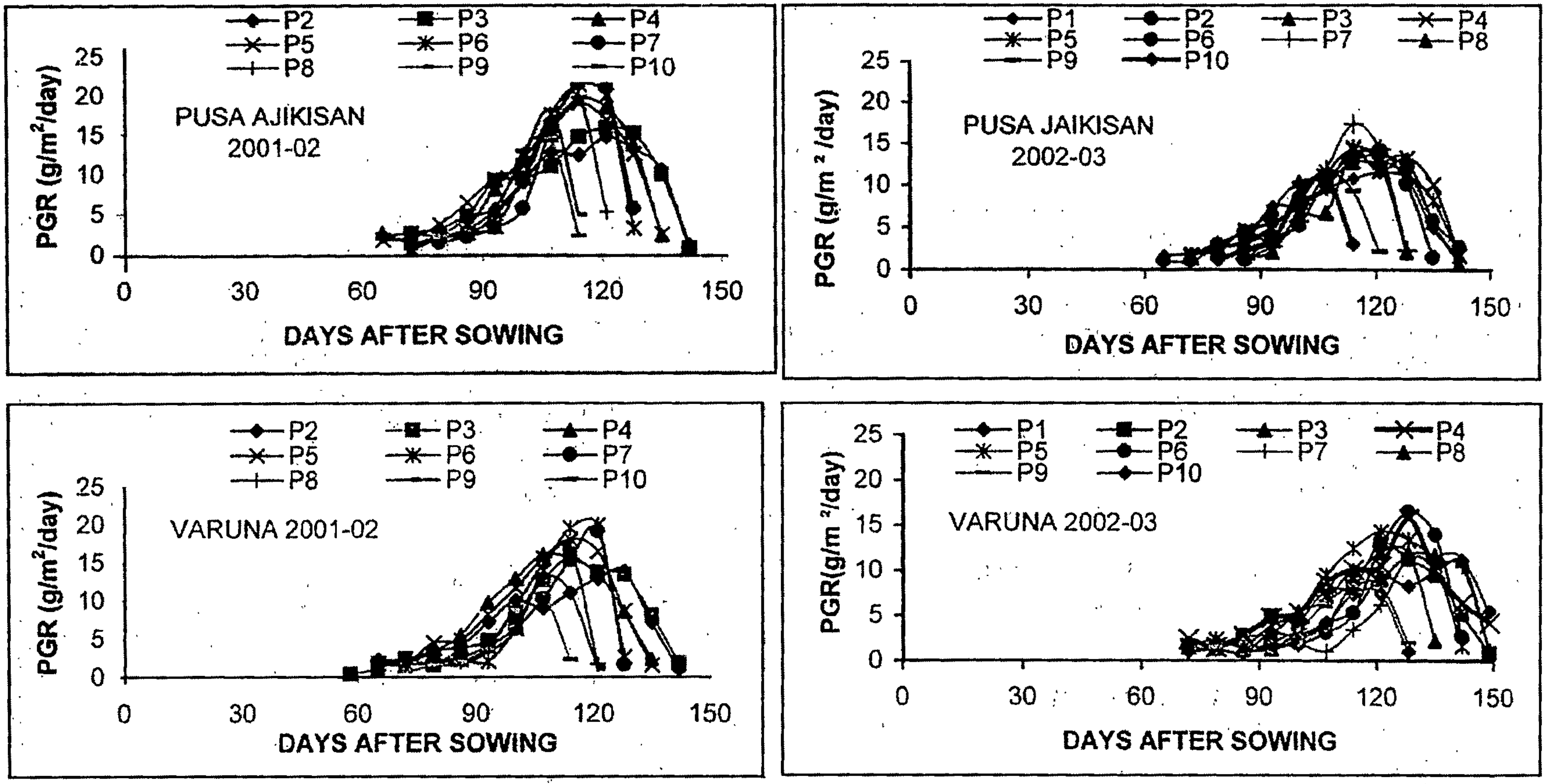

Fig. 4. Pod growth rate (PGR) in Pusa jaikisan and Varuna during rabi 2001-20 and 2002-03.

Table 1. Production of above ground biomass in Pusa Jaikisan and Varuna at maturity during rabi 2001-2002 and 2002-2003

Date of Sowing	Crop season	Biomass (g/m^2) Pusa Jaikisan	 Varuna
1st October	2001-02	*	*
	2002-03	1058	945
8th October	2001-02	1314	1214
	2002-03	1175	1046
15th October	2002-02	1370	1276
	2001-03	1235	1139
22nd October	2002-02	1436	1330
	2001-03	1267	1235
29th October	2001-02	1461	1361
	2002-03	1189	1142
5th November	2001-02	1180	1068
	2002-03	986	878
12th November	2001-02	1127	907
	2002-03	875	720
19th November	2001-02	892	758
	2002-03	712	674
12th November	2001-02	694	607
	2002-03	596	505
3rd December	2001-02	598	456
	2002-03	467	410

Table 2. Seed yield (q/ha) in Pusa Jaikisan and Varuna during rabi 2001-02 and 2002-03 seasons

	Pusa Jaikisan			Varuna		
Date of sowing	2001-02	2002-03	% Reduction	2001-02	2002-03	% Reduction
1st October	24.2	23.6	2.5	23.5	22.8	3.0
8th October	26.0	25.5	1.32	25.0	24.2	3.20
15th October	28.5	27.0	5.26	26.0	25.0	3.85
22nd October	29.2	27.6	5.48	26.8	26.2	2.24
29th October	29.6	26.3	11.50	27.4	25.2	8.03
5th November	21.4	18.7	12.62	19.5	17.3	11.28
12th November	20.0	16.5	17.50	17.5	15.5	11.43
19th November	15.2	12.1	20.39	13.0	11.0	15.38
26th November	9.5	8.0	15.79	10.0	8.2	18.00
3rd December	8.2	6.9	15.85	7.9	6.5	17.72

C.D. (P=0.05) : Cultivar= 1.58 & Date of sowing=0.71(2001-02) Cultivar= 0.9 & Date of sowing=0.40 (2002-03)

27.4 q/ha). In the second crop season too, in Varuna, the seed yields were marginally low ranging from 6.5 to 26.2 q/ha as compared to 6.9 to 27.6 q/ha in Pusa Jaikisan (Table 2), which could be attributed to higher leaf area index, biomass production, crop growth rate, pod growth rate besides relatively longer pod filling period in Pusa Jaikisan as compared to Varuna. The results are in conformity with the earlier findings of Katiyar and Chamola (1997), who reported that the seed yield of Pusa Jaikisan was significantly higher in Varuna due to tall growing and profuse branching habit, longer pod filling period, greater siliqua length and seed per siliqua in this cultivar.

On the whole, seed yield in different sowing dates varied significantly in both the cultivars and the seasons. The seed yields were maximum in the crops sown between 15th and 29th October and reduced as sowing was advanced or delayed. Higher seed yield in the crops sown on normal sowing time (15th October and 29th October) could be attributed to higher LAI, biomass production, crop growth rare, pod growth rate and longer seed filling period. In spite of longer seed-filling period in early sown crops (1st and 8th October sowings), the prevailing high temperatures during the early growth stages accelerated vegetative growth and forced the crop enter into pod development stage much earlier, which might have caused reduction in LAI, biomass production and ultimately the seed yield. Chauhan and Bhargave (1984) reported similar reduction in seed yields in the crops sown before 15th October. In case of late sowings (beyond 29th October) the crop took more time to reach 50 per cent flowering and the pod filling period was considerably reduced, which might have caused slow pod development with fewer and lighter seeds. Lower LAI, biomass production, crop growth rate and pod growth rate coupled with shorter pod filling duration in late sown crops might have caused reduction in seed yield. Similar reductions in seed yield in the late sowings were reported by Kar and Chakravarty (2001).

Thus, it can be concluded that the relatively low temperatures prevailed during the rabi 2002-2003 coupled with low bright sunshine hours during the month of January and February 2003 caused reduction of LAI, total biomass production, CGR and PGR leading western disturbances during the month of January and February 2003 affected the pod filling (early sowings) as well the vegetative growth (late sowings) of the crops, which was reflected in reduction in seed yield.

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EFFECT OF NUTRIENT MANAGEMENT USING AQUA-FERTILIZATION ON YIELD, QUALITY AND NUTRIENT UPTAKE OF WHEAT (*TRITICUM AESTIVUM* L.) UNDER DRYLAND CONDITIONS

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ABSTRACT

A field experiment was conducted at Indian Agricultural Research Institute, Research Farm, New Delhi during rabi 2001 and 2002. The data reveals that application of nitrogen upto 60 kg/ha has significantly increased grain and straw yields, harvest index, nitrogen and phosphorus content and their uptake and protein yield. Similarly placement of FYM either alone or in combination with urea significantly increased the above parameters over no FYM application. Combined application of urea and FYM proved better than their sole application. Combined use of 60 kg N through urea + 6 t FYM/ha proved better than equal dose of 90 kg N/ha supplied through urea. Aquafertilization with water volume upto 30,000 lit/ha has significantly increased above parameters over dry sowing.

Key words : Wheat, nutrient management, nitrogen, aquafertilization, FYM, dryland, yield, quality, protein yield.

Wheat is the second most important cereal crop after rice in India and occupying about 27.4 million hectares with annual production of 73.0 million tonnes (Anonymous, 2004-05). Inspite of expanding irrigation facilities, about 15 per cent of area is still unirrigated depending mainly on conserved soil moisture and rainfall received during winter season. The rainfall in these areas is generally low and unpredictable, therefore, the yield levels under such conditions are low. Proper nutrient management using combined application of chemical fertilizers and FYM and aquafertilization during sowing time seems to be the important practices to augment productivity of wheat in such areas. Aquafertilization not only increase the supply of nutrients and water to the growing seedlings but it also helps in better establishment and gives early boost to the plants.

MATERIALS AND METHODS

A field experiment was carried out during 2001-2002 and 2002-2003 at the farm of Indian Agricultural Research Institute, New Delhi to study the effect of nutrient management using aquafertilization on yield, quality and nutrient uptake of wheat under dryland conditions. There were twenty one treatment combinations comprising seven levels of nutrient management viz., control, 30, 60 and 90 kg N/ha through urea, 30 kg N through urea + 6 t FYM/ha (30+30), 60 kg N/ha through urea + 6 t FYM/ha (60+30) and 60 kg N through 12 t FYM/ha with three levels of water volume for aquafertilization (dry sowing, 15000 and 30000 litre water/ha). The experiment was conducted in randomized block design with three replications. Wheat variety PBW 175 was shown on middle of November with specially designed aqua-ferti-seed drill maintaining 25 cm row to row distance with 100 kg seed rate/ha. Well decomposed FYM having 0.5% N was applied as per treatment in mid July and was placed in soil about 7-8 cm deep with the help of soil turning plough for its proper decomposition. Urea was applied as per treatment as dry or as aqua. There was 19.8 and 107.8 mm rainfall during the crop growth period in first and second year, respectively. The crop was harvested manually and threshed using power operated thresher during third week of April.

RESULTS AND DISCUSSION

Grain and straw yield and harvest index

Application of nitrogen upto 60 kg/ha

significantly increased the grain and straw yields and harvest index in both the years. This might be due to role of nitrogen in increasing plant growth, photosynthetic area and better nutrient uptake through good root development and helping in better translocation of photosynthates resulting in better sink development.

Application of FYM either alone or in combination with urea significantly increased the above parameters over no FYM application in both the years. The combined application of 30 kg N through urea + 6 t FYM/ha (30 + 30 kg N/ha) was better for grain yield in first year and harvest index in both the years, while 60 kg N through urea + 6 t FYM/ha (60 +30 kg N/ha) proved better for grain yield in second year and straw yield in both the years. This might be due to synergistic relationship between FYM and urea and role played by FYM in increasing nutrient and water holing capacity of the soil and helped in increasing mineralization of the applied nitrogen and in increasing growth, nutrient uptake through better root development and finally better mobilization of photosynthates to the sink. Such results were earlier reported by Singh *et al.* (1981), Awasthi and Bhan (1993) and Chaplot *et al.* (2002).

Aquafertilization also helped in increasing above parameters by using water volume upto 30,000 lit/ha by improving germination, early good crop establishment, better root growth resulting higher nutrient uptake and better growth and higher mobilization of photosynthates from source to sink. Such results were earlier reported by Ray *et al.* (1974), Sharma and Parashar (1980) and Pramanik and Singh (2003).

Protein content and protein yield

Application of nitrogen upto 60 kg/ha significantly increased the protein content as well as protein yield in grin in both the years. This might be due to the fact that nitrogen is the major structural component of amino acids which act as building block for protein synthesis and increased yield resulted into higher protein yield. Such results were earlier reported by Awasthi and Bhan (1993).

Application of FYM either alone or in combination with urea has significantly increased the protein content as protein yield in grain in both the years. The combined application of 60 kg N/ha through urea + 6 t FYM/ha (60+30 kg N/ha) proved better for protein content in both the years and protein yield in second year while combined application of 30+30 kg N/ha proved better for protein yield in first year. This might be due to synergistic relationship between FYM and FYM helps in mineralization of applied nitrogen through improving soils physico-chemical and biological properties and improving nitrogen uptake through better root development resulting in highergrain yield and nitrogen content in grain. Such results were earlier reported by Chaplot *et al.* (2002).

Application of aquafertilization by using water volume upto 30,000 lit/ha has significantly increased the protein content and yield in grain in both the years. This might be due to its role in creating favorable environment for plant growth and improving root system for better nutrient and water uptake. It also helped in increasing uptake and improving grain yield resulting into higher protein content as well as protein yield in grain. Such results are in close conformity with Ray *et al.* (1974) and Pramanik and Singh (2003).

Nutrient uptake

Application of nitrogen upto 60 kg/ha has significantly increased the total N uptake in first year and total 'P' uptake in both the years while 'N' uptake in second year increased upto 90 kg N/ha. This might be due to higher initial moisture content and rainfall in second year compared to first year. The increased uptake is due to increased yield and content of nitrogen in grain as well as straw due to application of nitrogen.

Combined application of 60+30 kg N/ha proved better for total 'N' uptake in both the years and total 'P' uptake in second year while combined application of 30+30 kg N/ha proved better for total 'P' uptake in first year. Application of aquafertilization with water volume upto 30,000 lit/ha significantly increased the total 'N' and 'P' uptake in both the years. Since uptake is the function of nutrient content and respective yield of biomass, therefore, increased uptake of N and P due to application of above treatments is mainly due to increased yield of grain and straw and increased content of these nutrients in grain and straw.

Economics

Net income (Rs/ha) and B:C ratio was calculated for the above treatments and it was observed that highest net income was received with the combined application of 60+30 kg N/ha through urea + FYM, respectively in both the years while B:C ratio was highest with application of 60 kg N/ha through urea in first year and application of 90 kg N/ha through urea in second year, this differential response was mainly due to high rainfall and grain yield in second year.

For aquafertilization, higher net income and B:C ratio was received from water volume upto 30,000 lit/ha in both the years.

On the basis of the findings of this experiment, it may be concluded that under dryland conditions, combined application of 30 kg N/ha through urea + 6 t FYM/ha (30+30 kg N/ha) is better in less rainfall year and combined application of 60+30 kg N/ha (urea + FYM) is better for good rainfall year. Dryland wheat responded upto 60 kg N/ha. Aquafertilization with using water volume upto 30,000 lit/ha proved better in increasing grain and straw yield as well as net income and B:C ratio.

Table 1. Grain and straw yield (q/ha) and harvest index (%) of wheat as affected by nutrient management and aquafertilization

Treatments	Grain yield (q/ha)		Straw yield (q/ha)		Harvest index (%)	
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03
Nutrient management (kg N/ha)						
N_0	17.44	24.19	31.74	46.26	35.46	34.34
N_{30} through urea	20.38	28.96	33.12	50.52	38.09	36.44
N_{60} through urea	22.41	30.63	34.06	52.10	39.38	37.00
N_{90} through urea	21.97	31.37	33.50	52.88	39.62	37.23
N_{30} through urea + 6 t FYM/ha	24.15	32.03	34.21	53.30	41.38	37.54
N_{60} through urea + 6 t FYM/ha	24.93	33.08	34.95	54.26	41.63	37.84
N0 + 60 kg N through 12 t FYM/ha	22.57	30.29	34.25	51.76	39.73	36.92
SEm±	0.53	0.35	0.22	0.30	0.24	0.19
C.D. (5%)	1.52	0.99	0.62	0.87	0.70	0.53
Aquafertilization (Volume of water, lit/ha)						
A_0 (Normal sowing)	18.56	27.29	30.61	48.91	37.75	35.81
$A_{15,000}$	22.47	30.57	34.02	52.29	39.78	36.89
$A_{30,000}$	24.92	32.36	36.44	53.55	40.61	37.67
SEm±	0.35	0.23	0.14	0.20	0.17	0.12
C.D. (5%)	1.00	0.65	0.40	0.57	0.48	0.35

Table 2. Protein content and protein yield as affected by nutrient management and aquafertilization

Treatments	Protein content (%)		Protein yield (kg/ha)	
	2001-02	2002-03	2001-02	2002-03
Nutrient management (kg N/ha)				
N_0	10.41	10.18	181.55	246.26
N_{30} through urea	10.64	10.52	216.84	304.66
N_{60} through urea	10.81	10.70	242.25	327.74
N_{90} through urea	10.87	10.75	238.81	337.23
N_{30} through urea + 6 t FYM/ha	10.93	10.76	263.86	344.32
N_{60} through urea + 6 t FYM/ha	11.10	10.98	276.72	363.22
N0 + 60 kg N through 12 t FYM/ha	10.87	10.74	245.33	325.31
SEm±	0.05	0.04	4.75	5.46
C.D. (5%)	0.12	0.10	13.39	15.67
Aquafertilization (volume of water, lit/ha)				
A_0 (Normal sowing)	10.06	9.95	186.71	271.54
$A_{15,000}$	10.93	10.81	245.60	330.46
$A_{30,000}$	11.39	11.27	283.84	364.70
SEm±	0.03	0.02	3.12	3.44
C.D. (5%)	0.08	0.07	8.81	10.31

Table 3. Total uptake of nitrogen and phoshorus, net income and B:C ratio as affected by nutrient management and aquafertilization

Treatments	Total N uptake (q/ha)		Total N uptake (q/ha)		Total N uptake (q/ha)		B:C ratio	
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03
Nutrient management (kg N/ha)								
N_0	45.22	61.32	6.53	8.01	8,397	15,177	1.20	2.16
N_{30} through urea	52.94	74.88	8.07	10.13	9,786	18,205	1.28	2.39
N_{60} through urea	58.48	80.95	9.15	11.28	10,853	19,164	1.36	2.39
N_{90} through urea	57.95	83.24	9.06	11.73	10,475	19,789	1.32	2.49
N_{30} through urea + 6 t FYM/ha	62.70	86.82	10.12	12.24	11,346	19,744	1.33	2.32
N_{60} through urea + 6 t FYM/ha	66.93	91.78	10.87	13.14	11,623	20,158	1.31	2.28
N0 + 60 kg N through 12 t FYM/ha	59.20	81.29	9.28	11.43	10,401	18,343	1.22	2.16
SEm±	0.90	0.67	0.30	0.22	-	-	-	-
C.D. (5%)	2.58	1.93	0.86	0.62	-	-	-	-
Aquafertilization (volume of water, lit/ha)								
A_0 (Normal sowing)	44.41	65.18	6.41	8.85	8,154	16,794	1.05	2.16
$A_{15,000}$	59.70	82.82	9.56	11.83	10,550	18,885	1.27	2.29
$A_{30,000}$	69.38	92.62	11.33	12.79	11,102	20,283	1.54	2.50
SEm±	0.59	0.44	0.20	0.14	-	-	-	-
C.D. (5%)	1.70	1.27	0.56	0.41	-	-	-	-

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INFLUENCE OF CROPPING SYSTEMS AND NUTRIENT MANAGEMENT ON NUTRIENT UPTAKE, PROTEIN CONTENT, YIELD, PRODUCTIVITY AND NET RETURNS OF PEARLMILLET (*PENNISETUM GLAUCUM*)

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ABSTRACT

Field experiment was conducted to study the effect of cropping systems and nutrient management in pearlmillet on nutrient uptake, quality, yield and net returns. Highest nutrient uptake and protein content were observed with combined application of 60 kg N/ha + 40 kg P_2O_5/ha + 10 t FYM/ha + biofertilizer. There were no significant influence observed on yield in both the years of experimentation whereas total productivity was found superior with pearlmillet-wheat system and highest net returns also. Among nutrient management practices yield and total productivity was found highest with 60 kg N/ha + 40 kg P_2O_5/ha + 10 t FYM/ha + biofertilizer while highest net return was obtained with 60 kg N/ha + 40 kg P_2O_5/ha + 5 t FYM/ha + biofertilizer.

Keywords : Nutrient uptake, yield, productivity, net returns.

Agricultural land is inelastic and hence the increment of grain productivity per unit area, time and input is the only option left with us. In limited moisture availability areas, among the different cropping systems the pearlmillet-based cropping systems, if properly selected, planned and judiciously managed may prove a milestone in foodgrain production. Application of high technologies like inorganic fertilizers, pesticides, herbicides and energy intensive farm power machinery no doubt has increased production but has deteriorated the soil productivity and environmental quality. Soil fertility is a pre-requisite to land productivity. It is thus of paramount importance to substitute the inorganic fertilizers and the system productivity become sustainable through integrated use of organic and inorganic sources of nutrients (Singh and Yadav, 1992). However, a very few literature are available on this aspect and the present study was an attempt in this direction.

MATERIALS AND METHODS

Field experiment was conducted at IARI, New Delhi during 2002-02 and 2003-04 under dryland conditions. The trial was laid out in split-plot design with three replications. There were 3 cropping systems (pearlmillet-wheat, pearlmillet- chickpea and pearlmillet-mustard) in main plots and 9 fertility levels (control, 30 kg N/ha + 20 kg P_2O_5, 60 kg N /ha + 40 kg P_2O_5/ha, 5 t FYM/ha + biofertilizers (Azo. + VAM), 10 t FYM/ha + biofertilizer (Azo. + VAM), 30 kg N + 20 kg P_2O_5/ha + 5 t FYM/ha + Bio., 30 kg N/ha + 20 kg P_2O_5/ha + 10 t FYM/ha +Bio., 60 kg N/ha + 40 kg P_2O_5/ha + 5 t FYM/ha + Bio., and 60 kg N/ha + 10 t FYM/ha + Bio.) in sub plots. Soil of the experimental field was sandy clay loam in texture, low in available nitrogen, medium in available phosphorus and fairly high in potassium. The pH and organic carbon content of the soil was 7.2 and 0.50%, respectively. Pearlmillet cultivar 'Pusa-415' and wheat 'HD-2687', chickpea 'BG-256' and mustard 'Bio-902' were used as experimental materials.

RESULTS AND DISCUSSION

A perusal of data (Table 1) revealed that during both the years of experimentation, nutrient uptake and quality were non significantly influenced by cropping systems whereas nutrient management significantly influenced these. The highest value of these parameters was recorded with 60 kg N/ha + 40

Table 1. **Effect of cropping systems and nutrient management practice on total nutrient uptake and content of pearlmillet**

Treatments	N uptake (kg/ha)		P uptake (kg/ha)		Protein (%)	
	2002	2003	2002	2003	2002	2003
Cropping systems						
Pearlmillet-wheat	110.19	138.17	37.63	46.33	11.18	11.75
Pearlmillet-chickpea	107.85	136.05	37.70	45.03	11.00	11.56
Pearlmillet-mustard	107.94	136.76	37.49	45.43	10.93	11.75
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Nutrient management practices						
Control	71.65	86.13	24.37	29.07	10.12	10.56
30 kg N/ha + 20 kg P_2O_5/ha	105.33	137.35	36.39	45.07	10.87	11.75
60 kg N/ha + 40 kg P_2O_5/ha	121.32	150.31	41.49	49.12	11.37	12.00
5 t FYM/ha + bioferfilizer (Azo. + VAM)	94.68	120.76	32.44	39.70	10.75	11.25
10 t FYM/ha + biofertilizer (Azo. + VAM)	98.52	127.06	33.43	41.59	10.87	11.62
30 kg N/ha + 20 kg P_2O_5/ha + 5 t FYM/ha + Bio.	116.39	146.92	40.30	49.47	11.31	11.93
30 kg N/ha + 20 kg P_2O_5/ha + 10 t FYM/ha + Bio.	121.11	151.09	42.43	50.99	11.25	12.00
60 kg N/ha + 40 kg P_2O_5/ha + 5 t FYM/ha + Bio.	123.75	155.04	43.21	52.22	11.43	12.06
60 kg N/ha + 40 kg P_2O_5/ha + 10 t FYM/ha + Bio.	124.87	158.42	44.37	53.13	11.44	12.07
C.D. (p=0.05)	16.86	19.88	7.02	8.79	0.57	0.69

Table 2. Effect of cropping systems and nutrient management practices on grain yield, total productivity of systems and net returns of pearlmillet

Treatments	Grain yield (q/ha)		Total productivity in terms of pearlmilet grain equivalent (q/ha)		Net returns in terms of pearlmillet grain equivalent (Rs/ha)	
	2002	2003	2002	2003	2002	2003
Cropping systems						
Pearlmillet-wheat	24.18	27.92	69.16	72.51	36539	40760
Pearlmillet-chickpea	24.24	28.37	59.44	67.74	22960	30326
Pearlmillet-mustard	24.60	28.30	53.20	63.46	19423	30326
C.D. (P=0.05)	NS	NS	6.43	4.52		
Nutrient management practices						
Control	18.09	20.24	51.14	5713	21855	27081
30 kg N/ha + 20 kg P_2O_5/ha	23.95	27.88	59.15	66.29	26342	33231
60 kg N/ha + 40 kg P_2O_5/ha	26.75	30.39	59.15	69.68	27382	24512
5 t FYM/ha + bioferfilizer (Azo. + VAM)	21.78	25.58	56.93	63.77	24653	30880
10 t FYM/ha + biofertilizer (Azo. + VAM)	22.21	26.62	57.73	65.31	23941	30743
30 kg N/ha + 20 kg P_2O_5/ha + 5 t FYM/ha + Bio.	25.65	29.77	61.11	69.22	26235	44744
30 kg N/ha + 20 kg P_2O_5/ha + 10 t FYM/ha + Bio.	26.76	30.83	64/32	71.79	27441	32574
60 kg N/ha + 40 kg P_2O_5/ha + 5 t FYM/ha + Bio.	26.90	31.16	65.75	73.46	28445	33740
60 kg N/ha + 40 kg P_2O_5/ha + 10 t FYM/ha + Bio.	26.99	31.29	37.27	74.49	28371	35576
C.D. (p=0.05)	3.56	3.74	4.66	5.48		

kg P_2O_5,+ 10 t FYM/ha + biofertilizer followed by 60 kg N/ha + 40 kg P_2O_5/ha + 5 t FYM/ha + biofertilizer during both the years of experimentation. Higher NP uptake might be due to effective root system and increased concentration of nutrients in soil solution by more application of FYM, biofertilizer and chemical fertilizers. Cisse (1988) observed that application of organic manures in pearlmillet increased the major nutrients uptake after germination than in control. The protein content also increased with increase in level of fertilization alone or in combination with fertilizer. The similar results were reported by Kutty (1983).

Grain yield (Table 2) was not influenced by cropping systems in both the years of experimentation, while total productivity recorded significantly superior in pealmillet-wheat followed by perlmillet-chickpea and highest net returns also was obtained in pearlmillet-wheat. Nutrient management significantly influenced the grain yield and productivity due to various combinations of chemical fertilizer, FYM and biofertilizers. Maximum grain yield and productivity was recorded with 60 kg N/ha + 40 kg P_2O_5/ha + 10 FYM/ha + biofertilizer. Increased grain yield with increased nitrogen level was also recorded by Meena *et al.* (1988) and Sharma *et al.* (1999). Increase in yield might be due to higher N application resulted in vigorous vegetative growth and better carbohydrate utilization in addition to this FYM on decomposition adds several major and micronutrients and improvement in physical and chemical properties of soil, showed its impact on total productivity. Higher net returns in both the years were found maximum in pearlmillet-wheat due to better productivity and prevailing market prices and low cost of cultivation of the system. Maximum net returns in case of the nutrient management was obtained with 60 kg N/ha + 40 kg P_2O_5/ha + 5 t FYM/ha + biofertilizer, might be due to low cost of cultivation. These findings are supported by Hooda *et al.* (1991).

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GRAIN YIELD, WATER USE EFFICIENCY, ECONOMICS AND SOIL MOISTURE EXTRACTION PATTERN OF SUMMER GREENGRAM (*VIGNA RADIATA* VAR. *RADIATA*) AS INFLUENCED BY PLANTING AND IRRIGATION METHODS; IRRIGATION SCHEDULES AND VAM INOCULATION

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ABSTRACT

A field experiment was conducted to study the response of summer greengram to the irrigation regimes (two irrigations at pre-flowering and pod filling stages and three irrigations at branching, pre-flowering and pod filling stages), four planting and irrigation methods (flat bed planting and irrigation ridge planting and furrow irrigation, ridge planting and alternate furrow irrigation, furrow planting and irrigation method) and two levels of VAM (control and inoculation). The experiment was laid out in a split plot design with three replications. Greengram cultivar 'Pusa Vishal' produced significantly higher grain yield and had markedly higher net return and benefit: cost ratio under three irrigations, one each at branching, pre-flowering and pod filling stages by furrow planting and irrigation method with VAM inoculation. However, the water use efficiency was higher with two irrigations one each at pre-flowering and pod filling stages. So, an increase in irrigation frequency increased the seasonal water use but decreased the water use efficiency. The higher soil moisture was extracted under two irrigations at pre-flowering and pod filling stages applied by ridge planting and alternate furrow irrigation method without VAM (0-15 cm soil depth).

Key words : Summer greengram, irrigation regimes, land configuration, VAM, yield, water use efficiency.

Pulses are the cheapest and alternate source of animal protein, besides play a key role in improving and sustaining soil productivity on account of biological nitrogen fixation and addition of huge amount of organic matter to soil. Among all the pulses in India, greengram [*Vigna radiata* var. radiata] or Golden gram is third most important crop with an area of 3.1 mha with 1.1 mt of production (Economical and Statistical Survey, 2003). A practical approach to augment the production of this crop could be to grow it during summer season (March to mid June) in north - west India but it has to be essentially irrigated once at the natural precipitation during the period in this part of country is insufficient for raising greengram. During summer, it becomes very difficult to apply irrigation to greengram at frequent intervals and in adequate quantity, because irrigation water becomes scarce and water requirement of crops becomes high due to high evaporation demand. This clarifies the scope of irrigation scheduling, planting patterns and irrigation methods in summer greengram. Improved nutrient uptake by VAM fungi during periods of water deficit has been suggested as a mechanism for enhancing drought resistance (Nye and Tinker, 1977; Nelsen and Safir, 1982). VAM fungi and *Rhizobium* association increase the root volume and nutrient uptake by reducing the distance that the nutrients must diffuse to plant roots. Therefore, meeting the future demand of pulses from less favored environments is an uphill task before researchers, as it require location specific production technology to match the fragile environments.

MATERIALS AND METHODS

The field experiment was conducted during the summer season of 2004 at the farm of the Division of Agronomy, Indian Agricultural Research Institute, New Delhi The soil of the

Table 1. Yield attributes, grain yield, consumptive use of water and water use efficiency and economics of summer greengram as affected by different treatments

Treatments	No.of pods/ plant	No.of grains/ pod	Grain weight/ pod (g)	Test weight (g)	Grain yield (q/ha)	Consum-ptive use of water (cm)	Water use efficiency (kg/ha cm)	Net return (Rs/ha)	Benefit : cost ratio
Irrigation regimes									
Two irrigations at pre-flowering and pod filling stages	14.9	7.4	0.33	42.81	10.90	23.43	46.12	7373	0.79
Three irrigations at branching pre-flowering and pod filling stages	16.5	8.1	0.36	43.16	12.02	27.10	44.28	8700	0.90
C.D. (P=0.05)	**0.72**	**NS**	**0.030**	**NS**	**0.929**	-	-	-	-
Planting and irrigation methods									
Flat bed planting and irrigation	16.1	7.9	0.37	43.19	11.19	25.56	43.74	7880	0.85
Ridge planting and furrow irrigation	15.2	7.6	0.33	42.96	10.62	25.27	42.20	6709	0.69
Ridge planting and alternate furrow irrigation	13.7	7.2	0.31	42.42	10.24	24.20	42.24	6084	0.63
Furrow planting and irrigation	17.7	8.4	0.38	43.37	13.79	26.04	53.05	11473	1.20
C.D. (P=0.05)	**2.14**	**0.85**	**0.020**	**NS**	**0.562**	-	-	-	-
VAM									
Control	14.9	7.3	0.33	42.50	10.96	24.41	44.93	7333	0.78
Inoculation	16.5	8.2	0.37	43.47	11.95	26.12	45.69	8740	0.92
C.D. (P=0.05)	**1.51**	**0.60**	**0.014**	**00736**	**0.397**	-	-	-	-

experimental field was sandy loam (Topic ustochrepts) in texture with adequate drainage system, medium in available potassium (270 kg K_2O/ha) and low in organic carbon (0.42%), total N (0.041%) and available nitrogen (208 kg/ha), available phosphorus (9 kg/ha), electrical conductivity (0.38 dSm^{-1}) and alkaline (pH 7.8) in reaction. It contained 13.5 per cent soil moisture at field capacity (-0.03 MPa) and 5.35 per cent at permanent wilting point (-1.5MPa) with bulk density of 1.50 to 1.52 g cc^{-1}. The experiment was laid out in a split plot design with three replications and 16 treatment combinations of two irrigation regimes (two irrigations one each at pre-flowering and pod filling stages), four planting and irrigation methods (flat bed planting and irrigation, ridge planting and furrow irrigation, ridge planting and alternate furrow irrigation, furrow planting and irrigation) and two levels of VAM (control and inoculation). Seeds of greengram variety Pusa Vishal, inoculated with Rhizobium culture, was sown on 9th April, 2004 using *pora* method in flat beds and furrow planting method by dibbling on ridges. After thining the plants were maintained 7.5 cm apart in the rows maintained 30 cm apart. VAM mixed soil was applied to crop rows by *kera* method after planting. A buffer channel of 2 m was provided on all sides of $15m^2$ plots (sub plots). Measured quantity of irrigation as per treatments was applied using Parshal flume of 8.0 cm throat. Crop (net plot area of 7.2 m^2) from sub-plot of $15m^2$ was harvested on 30 June, 2004. The water use efficiency was worked out as grain yield (kg ha^{-1}) per unit of seasonal water use (water added + effective rainfall + Δ soil water). Due to low rain intensity, all the rain received was considered as effective. Soil moisture determination were made from the soil samples taken from 0-60 cm soil profile at 0-15, 15-30, 30-45 and 45-60 cm depth intervals.

RESULTS AND DISCUSSION

Grain yield and its attributes

Greengram variety Pusa Vishal gave significantly higher grain yield under three irrigations each one at branching, pre-flowering and pod filling stages, being 9.32 per cent higher than at two irrigations each at pre-flowering and pod filling stages (Table 1). Pods and plant and grain weight per pod were significantly higher under three irrigations and this could be attributed to higher grain yield recorded with three irrigations each at branching, pre-flowering and pod filling stages. Another reason for higher grain yield and yield attributes was higher soil moisture availability due to more number of irrigations and ultimately higher solubility of native nutrients from soil reservoirs.

Planting and irrigation methods influenced the grain yield significantly. Grain yield was significantly the highest (13.79 q/ha) at furrow planting and irrigation method followed by that of flat bed planting and irrigation method (11.19 q/ha). This could be attributed to the highest pods/plant (17.7), grains/pod (8.4), grain weight/pod (0.38 g) and test weight (43.37g) obtained under furrow planting and irrigation method. Another reason for the highest grain yield at furrow planting and irrgation method was higher soil moisture availability due to less loss of irrigation water in the form of evaporation and percolation from naked areas devoid of crop plants and negligible weed infestation in the furrow and ultimately less loss of water through evapotranspiration.

Inoculation produced significantly higher grain yield (11.95 q/ha) than control (10.96 q/ha). The possible other reasons for higher grain yield with inculcation were higher yield attributes by inoculation due to growth stimulation that proceeded to increase synthesis of food material in photosynthesis and their translocation to the reproductive sites which maintained their favorable source sink relationship. VAM fungi increased the root volume and nutrients (phosphorus) uptake by reducing the distance that the nutrients must diffuse to the plant roots. These findings have cognizance of the findings of Singh *et al.* (2004) and Kumar and Chandra (2003).

Consumptive use of water use efficiency

The consumptive use of water was lower (23.43 cm) with two irrigations at pre-flowering and pod filling stages than with three irrigations at branching, pre-flowering and pod filling (27.10 cm). The increase in consumptive use of water with three irrigations was mainly due to increased moisture supply by one extra irrigation at branching stage. The greater flow of water from

Table 2. Effect of irrigation regimes, planting and irrigation methods and VAM on soil moisture extraction pattern from different soil depths

Treatments	Moisture extraction pattern (%) Soil depth (cm) 0-15	15-30	30-45	45-60
Irrigation regimes				
Two irrigations at pre-flowering and pod filling stages	78.90	7.03	7.02	7.01
Three irrigations at branching pre-flowering and pod filling stages	76.32	8.11	7.98	7.63
Planting and irrigation methods and VAM				
Flat bed planting and irrigation without VAM	78.78	7.71	7.44	6.26
Flat bed planting and irrigation with VAM	75.82	7.84	7.56	8.75
Ridge planting and furrow irrigation without VAM	79.94	6.16	7.29	6.60
Ridge planting and furrow irrigation with VAM	74.73	9.00	8.36	7.91
Ridge planting and alternate furrow Irrigation without VAM	81.64	4.62	6.64	7.08
Ridge planting and alternate furrow irrigation with VAM	77.73	8.87	6.97	6.43
Furrow planting and irrigation without VAM	78.50	7.72	7.56	6.22
Furrow planting and irrigation with VAM	73.76	8.71	8.20	9.32

soil via plant to atmosphere due to lower stomatal resistance and larger leaf area might have increased transpiration rate at higher soil moisture content (Kramer, 1983). Among planting and irrigation methods, ridge planting and alternate furrow irrigation method maintained the lowest consumptive use of water (24.2 cm) because of less irrigation water was applied in this method, It was the highest (26.04 cm) at furrow planting and irrigation method, followed by flat bed planting and irrigation method (25.56 cm). The increase in consumptive use of water at furrow planting and irrigation method was mainly due to increased moisture supply by least losses of irrigation water in furrow planting itself. Inoculation maintained higher consumptive use of water (26.12cm) than control (24.41 cm). The increase in consumptive use of water with inoculation was mainly due to improved rooting parameter particularly root length, which extracted more soil moisture deeper from soil layers.

Two irrigations each at pre-flowering and pod filling stages acquired higher water use efficiency (WUE) of 46.42 kg/ha -cm than three irrigations given at branching, pre-flowering and pod filling stages (44.23 kg/ha-cm). Among planting and irrigation methods, furrow planting and irrigation method acquired the highest WUE (53.05 kg/ha-cm), followed by flat-bed planting and irrigation method (43.74 kg/ha-cm). Inoculation acquired higher water use efficiency (45.69 kg/ha-cm) than control (44.93 kg/ha-cm). Higher WUE in these treatments was acquired due to lower consumptive use of water and relatively higher grain yield, efficient use of water and soil moisture extraction from deeper soil layers.

Economics

The net return and benefit:cost ratio were were higher (Rs. 8700/ha and 0.90 respectively) with three irrigations at branching, pre-flowering and pod filling stages than two irrigations at pre-flowering and pod filling stages (Rs 7333/ha and 0.79, respectively). Among planting and irrigation methods, furrow planting and irrigation method maintained the highest net return (Rs. 11473/ha) and benefit:cost ratio (1.20). Similarly VAM inoculation gave higher net return (Rs. 8740/ha) and benefit:cost ratio (0.92) than control (Rs. 7333/ ha and 0.78 respectively). It was because of the highest grain and straw yields in these treatment combinations thereby fetching more net return and ultimately benefit:cost ratio as well.

Soil moisture extraction pattern

Soil moisture extraction decreased with the increase in soil depth, relatively higher from 0-15 cm soil layer (Table 2). This was mainly due to grater proliferation and spread of the roots of less irrigated plants in the upper soil layer because of less water was present in deeper layers. Frequently irrigated plants, irrigated at branching. pre-flowering and pod filling stage extracted a greater quantity of moisture from the deeper layers than the plant irrigated twice at pre-flowering and pod filling stages. A greater availability of water in deeper layers of frequently irrigated plants helped to meet the evapotranspiration demand and thus seemed to be the main factor responsible for greater water extraction (Kumar and Chandra, 2003). Among different planting and irrigation methods and VAM combinations, at 0-15 cm soil depths, the highest soil moisture was extracted (81.64% of total profile use) at ridge planting and alternate furrow irrigation method and control (no VAM), followed by ridge planting and furrow irrigation method and control (79.94%). So it confirms that, the crop met its water requirement from 0-15 cm soil depth.

From the results obtained in the investigation, it can be concluded that with three irrigations one each at branching, pre-flowering and pod filling stages to summer greengram by furrow planting and irrigation method with VAM inoculation, the water use can be economized profitably to reduce the potential of irrigation water in agriculture field.

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EFFECT OF MIXED BIO-FERTILIZERS AND NITROGEN LEVELS ON GROWTH, YIELD ATTRIBUTES AND YIELD OF PEARLMILLET

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The studies indicated that integration of chemical fertilizers with mixed bio-fertilizer will be able to maintain soil fertility and sustain crop productivity. However, the increased cost of the fertilizer nitrogen bars its use on a higher levels by small and marginal farmers in India. In order to find out some alternative, the use of mixed bio-fertilizer (*Azotobacter, Azosipirillum* and *Bacillus*) was studie as no specific information is available on the response of hybrid pearl millet to nitrogen in association with mixed bio-fertilizers the present study was undertaken on this aspect under irrigated conditions of semi arid region.

A field experiment was conducted at Research farm of CCS Haryana Agricultural University, Hisar during *kharif* 2002. Nine treatments viz., control, seed inoculation with mixed bio-fertilizers, 50 RDN, 75% RDN, 100% RDN, 125% RDN, 50% RDN + mixed bio-fertilizers, 75% RDN + mixed bio-fertilizers and 100% RDN + mixed bio-fertilizers were tested in randomized block design with four replications. The soil was sandy loam with pH 8.2, contained 124 kg available N, 9 kg P and 366 kg K ha^{-1}. The pearl millet hybrid HHB 94 was sown on 12th July, 2002. The nitrogen was applied in two equal splits (half at sowing and half at 3 weeks after sowing per treatments). A uniform dose of 20 kg P_2O_5 ha^{-1} was applied before sowing. Thinning, gap filling and other operations were carried out as recommended for pearl millet crop.

Increasing nitrogen levels revealed in significant increase in growth parameters. Plant height, leaf area/plant and dry matter accumulation/plant increased significantly by application of 125% RDN over remaining treatments except 100% RDN + mixed bio-fertilizers (Table 1). Application of 125% RDN resulted in significantly higher yield attributes (effective tillers/plant, ear length, ear girth and 1000-grain weight) except 100% RDN, 75% RDN + mixed bio-fertilizer and 100% RDN + mixed bio-fertilizer. However, ear length and 1000-grain weight in 75% RDN+mixed bio-fertilizer result significantly lower as compared to 125% RDN.

Application of 125% RD resulted in significantly higher grain and stover yield except 100% RDN, 75% RDN+mixed bio-fertilizer and 100% RDN+mixed bio-fertilizer. However, stover yield in 75% RDN+mixed bio-fertilizer significantly increased the grain and stover yield over control. Similarly, Gautam and Kaushik (1988) and Raghuvanshi *et al.* (1997) have also observed that grain and stover yield of pearl millet increased with inoculation of seed with bio-fertilizers.

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Table 1. Effect of mixed bio-fertilizer and nitrogen levels on growth, yield attributes and yield of pearl millet

Treatment	Plant height (cm)	No. of tillers/ plant	Dry matter accumulation/ plant (g)	No.of effective tillers/plant	Ear girth (cm)	Ear length (cm)	1000-grain weight (g)	Grain yield (q/ha)	Stover yield (q/ha)
Control	208.5	3.00	82.47	2.5	8.0	20.5	7.2	29.67	90.20
Seed with mixed bio-fertilizers	213.2	3.50	93.37	2.7	8.5	22.7	7.5	33.49	94.71
50% RDN	215.0	3.75	99.07	2.8	8.7	23.7	7.7	36.27	96.75
75% RDN	217.7	4.00	114.40	2.9	8.7	24.0	8.2	38.61	100.75
100% RDN	219.5	4.50	122.55	3.1	9.0	24.7	9.0	39.50	103.69
125% RDN	221.7	5.00	134.50	3.2	9.5	25.7	9.2	40.55	105.88
50% RDN+mixed bio-fertilizers	217.0	4.00	110.25	2.8	8.7	24.0	8.2		37.46
75% RDN+mixed bio-fertilizers	218.2	4.50	120.87	3.1	9.0	24.2	8.5	39.24	102.82
100% RDN+mixed bio-fertilizers	221.2	4.75	133.35	3.2	9.2	25.0	9.2	40.06	105.24
C.D. at 5%	2.14	0.96	2.58	0.22	0.76	1.23	0.56	1.91	2.15

RDN - Recommended dose of Nitrogen

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SCREENING OF CHICKPEA GENOTYPES FOR RESISTANCE OF *SCLEROTIUM* ROT UNDER ARTIFICIALLY INOCULATED CONDITION

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Chickpea is a leading pulse crop of India, grown in an area of 6.31 million ha with annual production of 5.08 million tones, contributing 29 per cent of area and 39.05 per cent of pulse production (Anonymous, 2002). It belongs to family Leguminoceae and sub family Papilionaceae. It is native of Indian sub continent and Central Asia Chickpea contains 21.1 per cent protein, 61.5 per cent carbohydrate, 4.5 per cent fat and is richer in phosphorous and calcium than other pulses. It is a rich source of protein and calorie due to better fibre digestibility and higher fat content. It is an important component of cropping system of subsistance farming in the Indian sub-continent. Some of these attributes together with its ability to derive more than 70 per cent of its nitrogen from symbiotic dinitrogen fixation make chickpea a promising crop for the sustainable agriculture. In Chhattisgarh, chickpea cultivation is limited to 1.79 lakh ha with with annual production of 1.05 lakh tones and average productivity of 590 kg per ha (Anonymous, 1999-2000).

Ninety genotypes of chickpea were screened for resistance to collar rot caused by Sclerotium rolfsii under artificially sick field condition. Sowing of genotypes was done of 19th Nov. 20002 in 10 trials. Each entry was sown in simple two row trial with two replication and at a spacing of 10 c 30 cm. Row length was 5 meter. Each row of different genotypes divided into two parts. One part was used for artificial inoculation of Sclerotium rolfsii and another part served as control and for seed procurement of similar lines. Inoculation was done at flower-bud initiation stage old culture of Scleratium rolfsii was inoculated in the collar region of plant. It was then covered with the soil and about one liter of water was sprinkled by hand shower in each row to provide moisture for optimum growth of fungus.

The observation of mortality (%) was recorded 3 times i.e. 7 days, 15 days and 21 days after inoculation. The mortality percent was converted into 0-5 scale (IIPR, 1999).

The location severity Index (LSI) was calculated using the following formula.

Sum of multiplication values of the scores and the number of genotypes under different scores

LSI = Total number of genotypes observed

Total genotypes: 90

Location Severity Index [LSI = (5.83)]

Chickpea genotype were evaluated under artifically inoculated field conditions for resistance to coolar rot. The data (Table 1) indicate that out of 90 genotypes, none of the genotype was completely free from the disease. However, 3 genotypes viz. PG 9414-7, BG 372 and H-00-256 were moderately resistant, 1 genotypes IPC 98-58 moderately susceptible, 4 genotypes i.e. BG 1003, BG 1053, LBEG-7 and RSG 7 were susceptible to disease under higher disease pressure (Location susceptible genotypes are GL-98014, GJG-9905, CSJ-281, CSJ-283, GJG-2018, GJG-9905, H99-278, IPC 97-72, IPC 2K-27, WCG 97-29, WCG-9737, C-235, CSJ-183, CSJ-225, H00-249, H99-65, IPC 2K-17, IPC 94-94, PG 9425-9, WCG 95-50, BG-1053, BG-1106, BGD-128, IPC 98-1, IPCK 99-18, RSG-7, GNG-1420, IPC 98-53, GJG-904, CSJ-225, CCSJ-252, GJG-2012, H99-264, IPC 98-22, PG 9425-5, PG 9425-9, BG-1107, BG-1108, HK98-155, NDGK 98-8, IPC-97-7, RSG-957, BG 1103, H82-2, IPC-97-7, RSG-957, BG 1103, H82-2, IPC 98-12, RSG-957, HK00-329, IPCK-162, IPCK-256, IPCK 97-77, IPCK 97-78, PG 95-332, PG 95-333, PG 97-313, BK BG 99-10, CSJ-291, IPC-9391, PG 9425-5, RSG-888, Vijay, CSK-104, PG-97-110, RSG-1431, RSG-888, RSG 902, RSG-931, BGD-127, CSJ-104, IPC-97-67, RG-96006, RSG 143-11, RSG-888, RSG-931, CSJK-1, HK-00-297, CSJK-4, BG-1105 and HK-1, HK-00-297, CSJK-4, BG-1105 and HK-94-134. Similar work was also reported by Gurha *et al.* (1982), Nene and Haware (1980) and Sugha *et al.* (1991).

Table 1. Screening of chickpea genotypes for their resistance to collar rot under artificial inoculation condition

Scale	Reaction	Number of genotypes	Name of genotype
0	Highly resistant	0	-
1 (Less than 10%)	Resistant	0	-
2 (10-20%)	Moderately resistant	3	PG 9414-7, BG-372, H-00-256
3 (21-30%)	Moderately susceptible	1	IPC 98-58
4 (31-40%)	Susceptible	4	BG 1003, BG 1053, LBEG-7, RSG-7
5 (above 40%)	High susceptible	82	GL-98014, GJG 9807, CSJ-281, CSJ-283, GJG-2018, GJG-9905, H99-278, IPC 97-92, IPC 2K-27, WCG 97-29, WCG-9737, C-235, CSJ-183, CSJ-225, H00-249, H99-65, IPC 2K-17, IPC 94-94, PG 9425-9, WCG 95-50, BG-1053, BG-1106, BGD-128, IPC 98-1, IPCK 99-18, RSG-7, GNG-1420, IPC 98-53, GJG-9804, CSJ-225, CSJ-252, GJG-2012, H99-264, IPC 98-22, PG 9425-5, PG-9425-9, BG-1107, BG-1108, HK98-155, NDGK 98-8, IPC-97-7, RSG-957, BG 9425-9, BG-1107, BG-1108, HK 98-155, NDGK 98-9, IPC-97-7, RSG-957, BG 1103, H82-2, IPC-97-7, RSG-957, HK 00-329, IPCK-162, IPCK-256, IPCK 97-77, IPCK 97-78, PG 95-332, PG 95-333, PG 97-313, BG BG 99-10, CSJ-291, CSJ-294, H99-109, H 99-119, IPC 200-7, IPC-9391, PG 9425-5, RSG-888, Vijay, CSJ-104, PG-97-110, RSG-1431, RSG-888, RSG 902, RSG-931, BGD-127, CSJ-104, IPC 902, RSG-931, BGD-127, CSJ-104, IPC-97-67, PG-96006, RSG 143-11, RSG-888, RSG-931, CSJK-1, HK-00-297, CSJK-4, BG-1105, HK-94-134.

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SOIL PROPERTIES, GROWTH BEHAVIOUR AND YIELD OF WHEAT (*TRITICUM AESTIVUM* L.) IN RELATION TO WEED MANAGEMENT PRACTICES UNDER DIFFERENT TILLAGE SYSTEMS

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ABSTRACT

A field experiment was conducted during the winter seasons of 2001-02 and 2002-03 at Kalyani, West Bengal, on sandy loam soil, to evaluate the effect of weed management practices on soil properties, growth behaviour, and yield of wheat (*Triticum aestivum* L.) under different tillage systems. Conventional tillage system recorded tallest plants (83.0 cm) with maximum dry matter accumulation at harvest. It had also highest leaf area index (LAI) and crop growth rate (CGR) followed by minimum and zero tillage system. All the growth characters like plant height, dry matter accumulation , CGR, LAI were maximum in weed free plots. These values with Metribuzin applied plots and Isoguard plus applied plots were very close to each other. Conventional tillage system recorded maximum number of spikes m^{-2} (286.2), filled grains per spike (38.4) and test weight (37.2g) resulting in highest grain yield of 3219.7 kg ha^{-1} followed by minimum and zero tillage system. Maximum grain yield was received from weed free plots (3260.2 kg ha^{-1}) followed by plots treated with Isoguard plus (3078.1 kg ha^{-1}). Maximum Weed Control Efficiency was recorded from conventional tilled plots (45.41%) and weed free plots (70.16%). Highest value of Weed Persistence Index was recorded from zero tilled plots (0.87) and weed free plots (0.97). Lowest bulk density and highest moisture content at 5-10 cm depth under minimum and zero tilled plots were at par. However, the application of Isoguard plus under minimum tillage system can be resorted to, with a maximum benefit : cost ratio of 2.09.

Key words : CGR, LAI, weed flora, tillage system, weed control methods, weed control efficiency, weed persistence index.

Cultivation of wheat after transplanted *kharif* rice is an usual practice in India, especially in the Indo-gangetic plains, eastern and north-eastern parts of the country covering about 11 million ha area. In West Bengal sowing of wheat, a thermo-sensitive crop needs to be completed by the end of November to obtain a good harvest, third week being the optimum sowing time. Considering the haevesting time of transplanted rice, climatic condition and land type, it becomes difficult very often to prepare the land for wheat and bring the desired tilth for sowing. Yield loss in wheat due to weed flora ranges from 20-40% depending upon the species and density of weeds (Mishra, 1997). Manual weeding is the traditional method of weed control adopted by the farmers, which is most uneconomical due to increased labour weges. In this context, control of weeds by herbicides can be preferred, as it has more potential, is economic, time and energy saving (Saraswat and Bhan, 1992). 2, 4-D is most commonly used herbicide in wheat that effectively controls only broad leaf weeds. Isoproturon is commonly used in wheat to control grasses. With continous use of same type of herbicides, development of resistance in weeds and shift in weed flora have started (Malik *et al.* 2000). This situation warrants a new direction in weed management with use of new herbicides or herbicides mixutres. Thakur 2002 suggested that resource conservation technologies especially zero tillage, reduced tillage in wheat, can help in controlling weeds, conserving soil moisture, establishing timely seedling and early seedling vigour. Zero tillage technology could effectively bring down the cost of production of wheat.

Considering the above informations, it is necessary to find out the effect of different tillage systems and weed control methods on wheat under West Bengal condition.

MATERIALS AND METHODS

The field expereiment was taken up in the District Seed Farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal durign the Winter seasons of 2001-02 and 2002-03. The soil of the experimental site was clay loam in texture with good drainge facility, having medium soil fertility and was neutral in reaction. The experiment was laid out in split-plot design with random allocation of three tillage systems in the main plot and five weed control methods in the sub-plot. The treatments were replicated thrice. The tillage systems in the main plot were zero tillage i.e., no plughihg and sowing by opening rows with tyne (T_1), minimum tillage i.e., two ploughing and sowing by opening rows with tyne (T_2) conventional tillage i.e., four ploughing followed by two laddering and sowing by opening the furrows with tyne (T_3) and the weed control methods in the sub-plot were post emergence application of Metribuzin @ 175 g a.i. ha^{-1} at 28 days after sowing (W_1), post emergence application of Isoguard plus (tank mixture of Isoproturon @ 750 g a.i. + 2, 4-D Na Salt @ 500 g a.i. ha^{-1} at 28 days after sowing (W_2), one hoeing at 28 DAS (W_3), weed free check (W_4) and weedy check (W_5). The variety used was Rajlaxmi (HP-1731). Fertilizer was applied @ 150 : 60 : 60 N : P_2O_5 : K_2O kg ha^{-1}. The growth characters like plant height and dry matter accumulation were recorded at harvest, crop grwoth rate (CGR) and leaf area index (LAI) were recorded at peak growth stage at 7-9 weeks after sowing and 9 weeks after sowing of the crop, respectively. The yield attributing characters and yield were recorded at harvest. The total weed count and dry weight of weeds at 40, 60, 80 days after sowing (DAS) were recorded. The weed control efficiency (WCE) and the weed persistence index (WPI) were calculated by using the formulae:

$$\text{WCE} = \frac{\text{Dry weight of weeds in control plot} - \text{Dry weight of weeds in treated plot}}{\text{Dry weight of weeds in control plot}} \times 100$$

$$\text{WPI} = \frac{\text{Dry weight of weeds in treated plot}}{\text{Dry weight of weeds in control plot}} \times \frac{\text{Weed count in control plot}}{\text{Weed count in treated plot}}$$

Soil physical properties like bulk density (BD) and soil moisture content were recorded by taking soil samples with core sampler before starting of the experiment and harvesting of the crop.

RESULTS AND DISCUSSION

Growth characters

Growth studies in wheat under different tillage systems revealed that growth attributes such as plant height, dry matter accumulation, leaf area index (LAI) and crop growth rate (CGR) varied significantly (Table 1). Conventional tillage system recorded the highest plant height (83.0 cm) and had maximum dry matter accumulation (1039.49 gm^{-2}) at harvest, which were at par with those in minimum tillage system. Leaf area index attained its maximum at 9 weeks after sowing. Maximum LAI of 4.12 recorded at that stage in conventional tillage system followed by minimum tillage system. Plants grown in conventionally tilled plots recorded highest value of CGR (13.17 gm^{-2} day^{-1}) at 7-9 weeks after sowing. These results were in the line of the findings of Singh *et al.* (1998).

Among different weed control methods, comparatively taller plants were recorded from weed free plots (82.2 cm) followed by Metribuzin and Isoguard plus treated plots. Maximum dry matter was accumulated in weed free plots (1143.32 g m^{-2}) followed by Isoguard plus (990.43 g m^{-2}) and Metribuzin (874.23 g m^{-2}). Highest value of CGR between 7-9 week stage (16.05 g m^{-2} day^{-1}) recorded from weed free plots closely followed by values obtained from Isoguard plus and Metribuzin applied plots. Maximum LAI of 3.91 was also recorded at 9 weeks after sowing followed by Metribuzin and Isoguard plus treated plots. These results were in conformity with the observations of Sardana *et al.* (2001).

Table 1. Growth characters, yield attributes and yield of wheat as influenced by tillage systems and weed control methods (pooled over 2001-2002 and 2002-2003)

Treatments	Plant height at maturity (cm)	Dry matter accumulation (g m^{-2}) at maturity	CGR (gm^{-2} day^{-1}) at 7-9 weeks after sowing	LAI at 9 week after sowing	No. of spikes m^{-2}	No. of filled grains spike^{-1}	Test weight of grains (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Tillage System (T)									
T_1 - Zero tillage	73.3	692.36	9.00	1.92	208.1	30.7	36.6	2101.6	5355.0
T_2 - Minimum tillage	82.3	999.98	10.12	3.71	277.8	35.2	36.8	2968.7	7032.7
T_1 - Conventional tillage	83.0	1039.49	13.17	4.12	286.2	38.4	37.2	3219.7	7464.5
SEm ±	0.89	31.614	0.359	0.106	4.01	0.27	0.10	115.83	214.06
C.D. at 5%	2.89	103.083	1.171	0.346	13.07	0.88	0.32	377.69	697.98
Weed control Method (W)									
W_1-Metribuzin	80.2	874.23	10.35	3.46	264.9	37.4	37.5	2856.3	6333.2
W_2-Isoguard plus	79.6	990.43	13.03	3.22	271.4	37.3	37.4	3078.1	7091.2
W_3-One hoeing	77.9	815.19	7.64	2.77	234.6	32.3	35.9	2543.9	6104.8
W_4-Weed free check	82.2	1143.32	16.05	3.91	283.6	37.6	38.5	3260.2	7809.9
W_5-Weedy check	77.7	729.88	6.76	2.89	232.3	29.2	34.9	2078.3	5747.7
SEm+	0.50	21.830	0.333	0.099	3.55	0.40	0.22	87.29	178.79
C.D. at 5%	1.42	62.106	0.947	0.282	10.09	1.13	0.63	248.34	508.65

Growth characters might had higher values in weed free plots and conventional tillage plots probably due to congenial growing environments of the crops.

Yield and yield attributing characters

The effect of different tillage systems on grain yield and straw yield of wheat were statistically significant in pooled data (Table 1). The maximum grain yield of 3,219.7 kg ha^{-1} and straw yield of 7464.5 kg ha^{-1} were obtained from conventionally tilled plots followed by minimum and zero tilled plots. Higher grain and straw yield in conventionally tilled plots might be attributed due to maximum number of spikes m^{-2} (286.2), maximum number of filled grains per spike (38.4) and maximum test weight (37.2 g). The reduction in grain yield with zero tillage system as compared to conventional and minimum tillage system were 34.7 and 29.2%, respectively. This result was in conformity with the findings of Das *et a*l. (1989).

The grain yield and straw yield of wheat were significantly influenced by different weed control methods in pooled data. The grain yield obtained from Isoguard plus (3078.1 kg ha^{-1}) was at par with weed free check (3260.2 kg ha^{-1}) and plot receiving Metribuzin (2856.3 kg ha^{-1}), though the highest grain yield was obtained from weed free check. Higher grain yield from weed free check plot might be due to maximum number of spikes m^{-2} (283.6), maximum number filled grains per spike (37.6) and maximum test weight (38.5 g). The grain yield obtained from plots receiving one hoeing significantly increased over weedy check. The weed control methods registered 22.4 to 56.9% increase in grain yield over weedy check. This result corroborates with the findings of Sardana *et al.* (2001). Weed free check recorded maximum straw yield (7809.9 kg ha^{-1}) followed by Isoguard plus (7091.2 kg ha^{-1}) .

The interaction of tillage systems and weed control methods did not influence the grain yield, straw yield, test weight and number of filled grains per spike.

Weed flora

The predominant weed species associated with the crop were noted and were grouped into grasses, sedges and broad leaved weeds. Among the grasses, the major weed flora were *Cynodon dactylon* L. *Lolium temulentum, Avena ludoviciana* Dur. and *Phalaris minor* Retz., among sedges *Cyperus rotundus* L. and among broad leaved weeds *Angallis arvensis* L., *Chenopodium album* L., *Cirsium arvense* L., *Convolvulus arvensis* L., *Fumaria parviflora* Lamb., *Lathyrus aphaca* L., *Medicago denticulate* Wild, *Melilotus alba* Lamk., *Melilotus indica* Lamk., *Physalis minima* L., *Polygonum plebejum* R. Br., *Rumex retroflex* L. and *Vicia sativa* L.

Weed dynamics

At 40, 60 and 80 days after sowing maximum number of weeds was recorded from zero tillage system (24.1, 32.6 and 38.5 m^{-2}) and the minimum being from conventional tillage system (Table 2). This finding was supported by Singh *et al.* (1998). The total number of weeds in relation to the weed control method was significant at all the stages of growth. Minimum number of weeds was recorded from weed free check followed by Metribuzin application and Isoguard plus application at all stages of crop. At 80 DAS, weed population recorded from Metribuzin treated plots (1417.84 m^{-2}, pooled) was at par with that from Isoguard plus treated plots (1434.39 m^{-2}, pooled). This finding was in the line with the reports of Sardana *et al.* (2001). Weed population in the experimental plots was significantly reduced due to the interaction effect of tillage systems and weed control methods at 40 DAS only during 2002-2003 and the pooled analysis of two years of experimentation.

At 40, 60 and 80 days after sowing, maximum dry weight of weeds were recorded from zero tillage systems (81.95, 218.93 and 423.23 gm^{-2}) and the minimum being from conventional tillage system. From the pooled analysis, it has been observed that dry weight of weeds recorded from the minimum tillage system and conventional tillage system at 40 and 60 DAS were at par with each other. The dry weight of weeds under different weed control methods were only significant at 40 DAS, where as it was non-significant at 60 and 80 DAS. Minimum dry weight of weeds was recorded from the weed free plots followed by plots receiving Metribuzin and Isoguard plus at all the 3 different stages of growth. Interaction between

Table 2. Weed dynamics in wheat, weed control efficiency and weed persistence index as influenced by tillage systems and weed control methods (pooled over 2001-02 and 2002-03)

Treatments	Total weed population (No. m^{-2})			Total dry weight of weeds (gm^{-2})			Weed control efficiency (%) at 80 DAS	Weed persistence index at 80 DAS
	40 DAS	60 DAS	80 DAS	40 DAS	60 DAS	80 DAS		
Treatment System (T)								
T_1 - Zero tillage	24.1 (600.75)	32.6 (1121.27)	38.5 (1537.90)	8.68 (81.95)	14.25 (218.93)	20.09 (423.23)	40.76	0.87
T_2 - Minimum tillage	21.6 (503.84)	29.6 (912.64)	37.1(1407.80)	6.46 (45.26)	12.35 (166.43)	19.30 (393.24)	45.50	0.71
T_3 - Conventional tillage	20.9 (455.84)	27.7 (802.60)	37.2(1439.47)	6.19(41.30)	11.50 (145.49)	19.10 (384.7)	45.51	0.86
SEm ±	0.26	1.29	0.88	0.437	0.664	0.376	-	-
C.D. at 5%	0.86	NS	NS	1.427	2.165	NS	-	-
Weed control Method (W)								
W_1-Metribuzin	19.5 (390.54)	26.6 (720.16)	37.5 (1417.84)	6.34 (41.72)	11.01 (122.92)	16.81 (284.22)	60.24	0.59
W_2-Isoguard plus	22.0 (496.49)	30.0 (914.05)	37.8 (1434.39)	6.94 (50.28)	11.43 (134.64)	17.90 (323.44)	54.40	0.68
W_3-One hoeing	23.4 (562.62)	34.15(1175.85)	40.7 (1661.24)	7.57 (61.30)	14.40 (212.18)	21.51 (463.66)	34.81	0.83
W_4-Weed free check	17.3 (305.70)	21.3 (468.83)	26.3 (704.85)	4.63 (22.28)	8.36 (72.57)	14.50 (212.44)	70.16	0.97
W_5-Weedy check	28.9 (845.36)	37.7 (1448.63)	45.6 (2090.29)	10.09 (105.27)	18.28 (342.46)	26.75 (717.81)	0.00	1.00
SEm+	1.85	0.70	0.54	0.250	0.288	0.299	-	-
C.D. at 5%	1.85	2.00	1.55	0.711	0.819	0.851	-	-

Figures in the parentheses aer original values : Square root transformation used for statistical analysis.

tillage systems and weed control methods on weed dry weight were significant only at 40 DAS.

Maximum weed control efficiency (45.51%) was recorded from conventional system being almost equal (45.50%) to minimum tillage system and the minimum (40.76%) from zero tillage system. Among different weed control methods, weed free plots recorded higher value of weed control efficiency (70.16%) followed by Metribuzin (60.24%) and Isoguard plus (54.40%). Highest value of weed persistence index (0.87) was recorded from untilled plots followed by conventionally tilled plots. Minimum tillage system recorded lowest persistence of weeds (0.71). Weed free plots recorded highest persistence of weeds (0.97) followed by one hoeing (0.83). The results indicated better suppression of weeds by herbicides as compared to cultural methods.

Production economics

One perusal of the data presented in Table 3, it was observed that the total cost of cultivation varied from Rs. 7838 ha^{-1}. to Rs. 12235 ha^{-1} with different tillage systems and weed control methods. The gross return varied from Rs. 13821 to Rs. 31670 ha^{-1}. Maximum gross return was recorded from weed free treatment under conventional tillage system followed by weed free check under minimum tillage, Isoguard plus application under conventional tillage system. Maximum net return was received from weed free plots under conventional tillage system (Rs. 19435 ha^{-1}) followed by Isoguard plus under conventional tillage system and Isoguard plus under minimum tillage system.

However, maximum benefit : cost ratio of 2.09 was recorded from the Isoguard plus treatment under minimum tillage system. Among the tillage systems, minimum tillage recorded maximum benefit : cost ratio (1 : 61) followed by conventional tillage and zero tillage system. Comparing the weed control methods, maximum benefit : cost ratio was recorded from Isoguard plus application (1.78) followed by application of Metribuzin (1.53).

Soil physical properties

Bulk density of soil at 0-5 and 5-10 cm depth

Table 3. Production economics of wheat cultivation under different tillage systems and weed control methods

Treatments	Yield (kg ha^{-1})		Common cost (Rs. ha^{-1})	Cost of tillage (Rs. ha^{-1})	Cost of weed control (Rs. ha^{-1})	Working capital (Rs. ha^{-1})	Interest on working capital (Rs. ha^{-1})	Toal cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit : Cost ratio
	Grain	Straw									
T_1W_1	2141	4828	7325.00	0.00	481.00	7806.00	546.42	8352.42	17883.80	9531.38	1.14
T_1W_2	2326	5411	7325.00	0.00	375.00	7700.00	539.00	8239.00	19528.60	11289.60	1.37
T_1W_3	2012	5094	7325.00	0.00	621.00	7946.00	556.22	8502.22	17140.40	8638.18	1.02
T_1W_4	2450	6933	7325.00	0.00	2235.00	9560.00	669.20	10229.20	21309.80	11080.60	1.08
T_1W_5	1582	4578	7325.00	0.00	0.00	7325.00	512.75	7837.35	13820.80	5983.05	0.76
T_2W_1	3019	6845	7200.00	1000.00	481.00	8681.00	607.67	9288.67	25240.00	15951.33	1.72
T_2W_2	3390	7762	7200.00	1000.00	375.00	8575.00	600.25	9175.25	28387.20	19211.95	2.09
T_2W_3	2668	6454	7200.00	1000.00	621.00	8821.00	617.47	9438.47	22548.40	13109.93	1.39
T_2W_4	3568	8189	7200.00	1000.00	2235.00	10435.00	730.45	11165.45	29889.40	18723.95	1.68
T_2W_5	2200	5964	7200.00	1000.00	0.00	8200.00	574.00	8774.00	18978.40	10204.40	1.16
T_3W_1	3410	7229	7200.00	2000.00	481.00	9681.00	677.67	10358.67	28207.40	17848.73	1.72
T_3W_2	3520	8176	7200.00	2000.00	375.00	9575.00	670.25	10245.25	29545.60	19300.35	1.88
T_3W_3	2953	6586	7200.00	2000.00	621.00	9821.00	687.47	10508.47	24622.60	14114.13	1.34
T_3W_4	3763	8882	7200.00	2000.00	2235.00	11435.00	800.45	12235.45	31670.20	19434.75	1.59
T_3W_5	2454	6450	7200.00	2000.00	0.00	9200.00	644.00	9844.00	21048.00	11204.00	1.14

Table 4. Physical properties of soil as influenced by tillage systems

Tillage systems	Bulk density (gm cm^{-3})		Moisture content (%)	
	0-5 cm	5-10 cm	0-5 cm	5-10 cm
T1 : Zero Tillage	1.35	1.37	32.13	30.84
T2 : Minimum Tillage	1.33	1.35	35.68	31.23
T3 : Conventional Tillage	1.26	1.34	39.64	35.75
SEm ±	0.022	0.031	0.474	0.693
C.D. at 5%	0.087	N.S.	1.863	2.721

has been presented in Table 4. The data reveals that tillage system significantly influenced the bulk density of soil in the upper 0-5 cm depth. At 0-5 cm depth, lowest bulk density was recorded with conventional tillage systems (1.26 gm^{-3}), followed by minimum tillage system (1.33 g cm^{-3}) However, effect of tillage on the bulk density of soil in lower depth (5-10 cm) was non-significant.

It is evident from the data presented in Table 4, tillage systems influenced the moisture content of soil at both the depths. Maximum soil moisture content was recorded with conventional tillage system (39.64 g/g at 0-5 cm and 37.35 g/g at 5-10 cm depth) followed by minimum tillage and zero tillage system. However, no significant difference in moisture content of soil between minimum tillage system and zero tillage system was observed at 5-10 cm soil depth.

Therefore, it could be concluded that wheat can be grown under minimum and zero tillage systems, since they reduce the turn round time, incurred less cost and result in remunerative return. Among chemical methods, post emergence application of Isoguard plus & Metribuzin can be adopted instead of manual weeding for effective control of weeds. However, Isoguard plus treatment under minimum tillage system can very well be practiced, that have a maximum benefit : cost ratio.

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SEED YIELD COMPONENTS IN IMPROVEMENT OF CHICKPEA (*CICER ARIETINUM* L.)

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Abstract

In 10 varieties of bengalgram, out of 5 component characters studies; pods per plant, height and seed weight had high estimates of heritability and genetic advance. The seed yield was positively and significantly correlated with pods per plant and seed weight, while it was negatively associated with flowering and maturity. Path analysis revealed simultaneous selection for more pods per plant, early maturity coupled with short stature would bring overall improvement in chickpea.

Key world : Variability, heritability and path analysis.

The success of any breeding programme depends on the amount of variability present for different characters in a population and its efficient management and utilization. In order to exploit the different types of gene action, information on the relative magnitude of genetic variability in the population, heritability and genetic advance of important yield contributing traits is essential. Heritability and genetic advance is of more value in predicting the effect of selection. If the heritability is mainly due to additive gene effects, the realized genetic gain would be high in comparison to the situation, where both, additive and non-additive gene effects are involved. Character association reveals the type, nature and magnitude of correlation between yield components with yield and among themselves. Understanding inter-relationships of yield components is essential for improvement in yield through effective selection. Path analysis serves to know the direct and indirect effects of component characters on yield.

Chickpea (*Cicer arietinum* L.) is the most important pulse crop of the country and in recent years, the area, production and productivity is in the increasing trend due to its profitability under rainfed conditions. An understanding of variability present in the material is a prerequisite for any crop improvement programme. Hence, an attempt has been made in this study to suggest effective selection model for identifying ideal type through study of variability and path analysis.

Material and Methods

The experimental material consisted of 10 genotypes of Bengalgram tested during Rabi 2001-2002, 2002-2003 and 2003-2004 in Randomized Block design with 3 replications at Agricultural Research Station, Madhira. Each entry was sown in 6 rows of 4 m length with spacing of 30 cm x 10 cm. Observations on pods per plant, plant height, seed weight and seed yield per plant were recorded on 5 random plants in each plot in all the replications. Days to flowering were computed following standard procedures (Johnson *et al*, 1995; Dewey and Lu, 1959).

Results and Discussion

The genotypes differed significantly for all the six characters indicating the presence of wide variation in the present material studied. The estimates of genetic parameters are presented in Table 1. The values of phenotypic coefficients of variation are higher than phenotypic coefficients of variation indicating the influence of environmental factors. The highest genotypic coefficient of variation was observed for pods

Table 1. Estimates of genetic parameters for 6 charactes in chickpea

Character	General mean	Range of variation	Range (%)	Coefficient of variation (%)		Heritability (%)	Genetic advance	Genetic advance as percentage of mean
Days to 50% flowering	43.78	40-47	17.50	6.24	5.05	65.80	4.74	10.82
Days to maturity	102.03	93-113	21.51	9.27	7.66	68.30	17.05	16.71
Plant height (cm)	43.74	38-53	39.47	15.63	13.83	78.40	14.14	32.33
Pods per plant	48.16	38-63	65.71	23.16	21.49	86.10	25.34	52.66
100-seed weight (g)	11.99	10-15	50.00	15.72	13.26	71.10	3.54	29.53
Grain yield (kg/ha)	1052.44	800-1200	50.00	23.76	8.97	14.30	94.13	8.94

per plant followed by plant height and seed weight. Thus, there is a scope for improvement in these by selection Similar results were reported earlier by Raval and Dobaria (2003). Heritability, in broad sense in the ratio of genotypic variance to the phenotypic variance. The high heritability estimates coupled with moderate genetic advance of pods per plant, plant height and days to maturity indicates additive gene action for these traits. High heritability and low genetic advance for days to 50% flowering and seed weight suggests non additive gene action and hence selection for such characters may not be rewarding.

The genotypic and phenotypic correlation coefficients between grain yield and its components are presented in Table 2. The genotypic correlation coefficients are higher than phenotypic correlation coefficients indicating the environmental influence on expression on these characters. Pods per plant and seed weight displayed significant and positive correlation with seed yield per plant. The present results strengthen the earlier findings (Maloo and Sharma, 1997; Misra *et al.*, 1988; Singh *et al.*, 1997; Ravel and Dobaria 2003). Seed yield exhibited negative association with days to 50% flowering days to maturity and plant height. Since early maturity and short stature are considered as important criteria for ideal plant type, this relationship seems to be desirable direction.

Days to 50% flowering had significant and positive correlation with days to maturity, which enables in identifying and deciding the duration of the crop. Both these traits had positive and significant association with pods per plant. Such relationship among component characters may bring collective improvement in them and inturn, the seed yield. Seed weight showed significant negative association with all other component characters but it was positively correlated with seed yield.

Grain yield is a complex character resulting from interaction of component traits, which are either positively or negatively correlated with each other. Better understanding of direct and indirect influences of various characters on grain yield, would, power, emerge from the path analysis which showed that pods per plant and plant height contributed very high positive direct effects on yield (Table 3). These characters also displayed significant positive correlation with yield. Days. to 50% flowering had negative direct on yield but supplemented yield indirectly through seed weight and plant height. Seed weight, though exerted negative direct effect, its positive association with yield was mainly due to its indirect effects via days to 50% flowering, days to maturity and pods per plant. The residual effect is of moderate suggesting that some other yield attributes not included in the present study are also involved in the path analysis.

Critical analysis of path coefficients revealed that more emphasis must be given during selection to have dwarf and early plant type with more number of pods per plant.

Table 2. Phenotypic and genotypic carrelation between yield and other component characters in chickpea

Character		Days to maurity	Plant height	Pods per plant	100-seed weight (g)	Grain yield (kg/ha)
Days to 50% flowering	P	0.2908*	-0.0570	0.2724*	-0.4776*	-0.1184
	G	0.3883	-0.0321	0.3381	-0.7727	-0.1310
Days to maturity	P		-0.1195	0.2433**	-0.2233*	-0.0953
	G		-0.1132	0.2620	-0.3281	-0.1419
Plant height	P			0.1730	-0.4031**	0.0266
	G			-0.2029	-0.5228	0.0100
Pods per plant	P				-0.2523*	0.3267**
	G				-0.3240	0.9337
100-Seed weight (g)	P					0.2733*
	G					0.3460

P=Phenotypic G=Genotypic

** Significant at 1% level

* Significant at 5% level

Table 3. Direct and indirect effects of path analysis in chickpea

Character		Days to 50% flowering	Days to maturity	Plant height	Pods per plant	100-seed weight (g)	Correlation with yield
Days to 50% flowering	P	-0.1647	-0.0479	0.0094	-0.0449	0.0786	-0.1184
	G	-0.8129	-0.3172	0.0752	-02762	0.6312	0.1070
Days to maturity	P	-0.0257	-0.0883	0.0106	-0.0126	0.0197	-0.0953
	G	0.0800	0.0260	0.0233	0.0334	-0.0676	0.1419
Plant height	P	0.0005	0.0011	0.0092	0.0016	-0.0037	0.0266
	G	-0.0313	-0.0385	0.3397	-0.0689	0.1776	0.0100
Pods per plant	P	0.1098	0.0577	-0.0697	0.4029	-0.10116	0.3267*
	G	0.3854	0.1846	-0.2313	1.1399	-0.3693	0.9337
100-Seed weight (g)	P	-0.0384	-0.0179	0.1324	-0.0203	-0.0803	0.2733*
	G	0.2518	0.1069	-0.1704	-0.1056	-0.3259	0.3460

P=Phenotypic G=Genotypic

* Significant at 5% level

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DRYMATTER PRODUCTION AND NUTRIENT UPTAKE BY FODDER SORGHUM - INDIAN MUSTARD SEQUENCE AS AFFECTED BY NUTRIENT MANAGEMENT

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ABSTRACT

An investigation was carried out during *kharif* and *rabi* season of 2003-04 and 2004-05 to study the effect of nutrient management on dry matter production and nutrient uptake by fodder sorghum-mustard sequence. The results revealed that biomass production, N and P uptake by sorghum were significantly higher due to RDF (60 kg N + 30 kg P_2O_5/ha). It was on par with half RDF + biofertilizers in drymatter production. RDF produced 52.5 and 39.5 per cent more drymatter than control in 2003 and 2004, respectively. Previously applied RDF to sorghum has significantly increased the drymatter production and N and P uptake by mustard. Among directly applied nutrients, RDF (80 kg N + 40 kg P_2O_5/ha) was significantly superior in biomass production, N and P uptake by mustard as well as fodder sorghum-mustard sequence. Mustard under RDF the removed 62.7 and 70.0 per cent more N and 146.1 and 109.0 per cent more P than control, in 2003-04 and 2004-05, respectively. Fodder sorghum-mustard sequence extracted 150.8 kg N and 49.8 kg P/ha from directly applied RDF.

Keywords : Dry matter, nutrient uptake, fodder sorghum, Indian mustard.

Due to its high productivity and low water requirement, Indian mustard can be grown in succession to maize, sorghum, groundnut, sunflower, mungbean, urdbean and rice in North-West India. Among these, sorghum and mustar are exhaustive. Sorghum being a heavy feeder on nutrients is known to exhibit inhibitory effect on the performance of succeeding mustard. Though nutrients play a pivotal role in improving crop production the global crises of energy and higher cost of fertilizers necessitates their economic use. To economise inorganic fertilizers and obtain maximum returns, biofertilizers like *Azotobacter* and phosphorus solubilizing bacteria (PSB) have been recommend. Some of the cropping systems remove 400 to 900 kg /ha of nutrients under higher productivity systems (Hegde, 2003). Unless the nutrients exhausted by the preceding crops are replenished, expecting higher productivity from succeeding crop will be nightmare. A lot of information is available on nutrient management in sole crop of mustard. However, the information on nutrient management on fodder sorghum-mustard sequence is meagre. Hence, the present study was undertaken.

MATERIALS AND METHODS

A field experiment was conducted at New Delhi, during rainy (*kharif*) and winter (*rabi*) seasons of 2003-04 and 2004-05 on sandy loam soil under irrigated conditions. The experiment was laid out in split-plot design. The four treatments in fodder sorghum comprised of control, half RDF (30 kg N + 15 kg P_2O_5 /ha), RDF (60 kg N + 30 kg P_2O_5/ha) and half RDF + biofertilizers (*Azotobacter* + PSB.) The six treatments imposed in mustard were, control, 40 kg N/ha, 80 kg N/kg, half RDF (40 kg N + 20 kg P_2O_5 /ha), RDF (80 kg N + 40 kg P_2O_5/ha) and half RDF + biofertilizers (*Azotobacter* + PSB). Fodder sorghum (PC-9) was sown at a spacing of 30 x 10 cm on 27 June in 2003 and 26 June in 2004. In the subsequence *rabi* season, the mustard cultivar Pusa Jagannatha was sown at a spacing of 45 x 10 cm on 20 October during both the years of investigation. Regarding biofertilizers, *Azotobacter chroococcum* and *Pseudomonas striata* (PSB) were used for seed treatment of fodder sorghum and mustard. The soil of experimental site had 135.5 kg available N, 18.5 kg P and 225.5 kg K. The pH and organic carbon content of soil were 7.1 and 0.4, respectively.

RESULTS AND DISCUSSION

Effect on drymatter production and nutrient uptake of fodder sorghum

The sorghum fed with recommended dose of N and P (60 kg N + 30 kg P_2O_5 /ha) produced significantly higher drymatter than other treatments in both the years (Table 1). It could be due to the fact that, N and P supplied in suitable proportions might have encouraged the sorghum crop to produce highest dry matter. Half RDF + biofertilizers was found to be at par with RDF in biomass production of fodder sorghum. The reason for this could be that crop might have utilized N and P applied though inorganic fertilizers in the initial stages. In the later stages, N and P fixed and mobilized by *Azotobacter* and PSB, respectively might have been efficiently utilized by sorghum crop. Similar results were earlier reported by Subha and Giri (2003). RDF increased the drymatter production by 52.5 and 39.5 per cent as compared to unfertilized control in first and second year of experimentation, respectively. Data further revealed that N and P uptake by sorghum were significantly higher due to application of RDF. However, it was found to be in parity with half RDF and half RDF + biofertilizers in this respect might be due to higher biomass production, nutrients concentration of sorghum under these treatments than others. Sorghum crop removed 62.7 and 70.0 per cent more N and 146.1 and 109.0 per cent more P under RDF than control in 2003 and 2004, respectively.

Effect on drymatter production and nutrient uptake by mustard

Drymatter production of mustard was significantly influenced by preceding and direct applied nutrients except in second year due to preceding treatments (Table 2). RDF (60 kg N + 30 kg P_2O_5 /ha) applied in preceding sorghum being at par with half RDF + biofertilizers produced significantly higher quantity of biomass of mustard. In case of directly applied nutrients, RDF (80 kg N + 40 kg P_2O_5 /ha) supplied to mustard produced significantly higher biomass than rest of the treatments. However, RDF was found to be at par with half RDF + biofertilizers in second year. RDF was significantly superior to 80 kg N/ha in both the years. The highest amount of biomass recorded with RDF could be due to the fact that, adequate availability of N and P might have significantly improved the growth characters, yield attributes, seed and stover yield. This result has been confirmed by Sihgh and Brar (1999).

The results further revealed that significantly higher amount of N and P uptake by mustard were recorded due to directory applied RDF (80 kg N + 40 kg P_2O_5 /ha) than rest of the treatments. This expected phenomenon might be due to the consequence of significantly higher biomass and N and P concentration recorded with RDF. Lal *et al.* (1997) reported similar results. Half RDF + biofertilizers was found to be at par with RDF in second year only. Similarly 40 gk N and 80 kg N/ ha did not differ significantly in respect of N and P uptake by mustard in second year. Mustard could remove 43.9 and 41.8 kg more N due to RDF than control in first and second year, respectively. Similarly, P extracted by mustard crop under RDF was higher by 13.5 and 17.6 kg P in comparison to control in 2003-04 and 2004-05, respectively.

Effect on nutrient uptake of fodder sorghum-mustard sequence

Nutrient uptake by fodder sorghum-mustard sequence has been presented in Table 3. Among preceding treatments, recommended dose of fertilizer (60 kg N + 30 gk P_2O_5 /ha) enabled the sequence to remove the highest amount of N (146.9 kg/ ha) and P (51.2 kg P/ha) as compared to all other treatments. Similarly directly applied RDF (80 kg N + 40 kg P_2O_5 /ha) also recorded maximum amount of N (150.8 kg N/ ha) and P (49.8 kg P /ha). It was higher than rest of the treatments under test. It might be due to higher biomass produced as well a N and P concentration under RDF. Fodder sorghum-mustard supplied with RDF removed 58.7 and 45.6 pre cent more N and P, respectively. Application of 40 kg P_2O_5 along with 80 kg N/ ha could encourage the sequence to extract 35.3 kg more N and 9.7 kg/ha more P over application of 80 kg N/ha alone.

Table 1. Drymatter production and nutrien uptake by fodder sorghum as affected by nutrient management

Treatment	Drymatter (t/ha)		N uptake (kg/ha)		P uptake (kg/ha)	
	2003	2004	2003	2004	2003	2004
Control	4.00	4.30	36.5	34.1	7.8	11.1
Half RDF	5.00	4.70	49.4	39.0	11.9	15.3
RDF	6.10	6.00	69.2	58.0	19.2	23.2
Half RDF + Biofertilizers	5.80	5.90	59.4	53.3	16.4	20.8
CD (P=0.05)	0.80	0.48	7.5	4.5	3.2	1.5

Table 2. Drymatter production and nutrients uptake by mustard as affected by preceding and directly applied nutrients

Nutrients applied	Drymatter (t/ha)		N uptake (kg/ha)		P uptake (kg/ha)	
	2003	2004	2003	2004	2003	2004
Preceding						
Control	5.04	6.54	57.3	60.1	20.1	24.4
Half RDF	6.41	6.81	66.0	65.7	23.7	26.7
RDF	7.09	7.39	77.0	79.6	28.4	30.2
Half RDF + Biofertilizers	6.95	7.13	75.5	75.7	27.2	28.1
CD (P=0.05)	0.34	MS	7.2	5.0	3.7	NS
Direct						
Control	5.51	5.45	48.3	48.2	18.8	18.3
40 kg N/ha	5.89	6.54	54.5	62.2	20.8	24.0
80 kg N/ha	6.28	6.76	62.7	67.0	20.8	24.0
Half RDF	6.84	7.20	75.6	74.2	26.0	28.8
RDF	7.76	8.27	92.2	90.0	32.3	35.9
Half RDF + Biofertilizers	7.32	7.60	80.8	80.1	28.4	30.9
CD (P=0.05)	0.31	0.68	5.2	4.4	2.0	3.1

Table 3. N and P uptake by fodder sorghum-mustard sequence as influenced by preceding and directly applied nutrients (mean of two years)

Nutrients applied	Nutrient uptake (kg /ha)	
	N	P
Preceding		
Control	94.0	31.3
Half RDF	113.3	38.9
RDF	146.9	51.2
Half RDF + Biofertilizers	132.1	45.2
Direct		
Cotrol	95.0	34.2
40 kg N/ha	110.1	37.8
80 kg N/ha	115.5	40.1
Half RDF	122.0	43.1
RDF	150.8	49.8
Half RDF + Biofertilizers	135.0	45.2

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ANALYSIS OF GRAIN YIELD FROM A LONG-TERM EXPERIMENT ON INTEGRATED NUTRIENT MANAGEMENT IN SORGHUM-WHEAT CROPPING SYSTEM

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ABSTRACT

Grain yield data from a long-term experiment on integrated nutrient management in sorghum-wheat cropping sequence conducted during 1984-85 to 2002-03 at Akola centre have been analyzed. Analysis revealed that year, treatment and replication effects were highly significant and so were the two-factor interactions except the treatment x replication interaction. The treatment with 50% recommended NPK dose through fertilizers + 50% N through farmyard manure in *kharif* and 100% recommended NPK dose through fertilizers in *rabi* came out to be the best treatment for the centre in terms of giving highest grain yield for both the crops together. However, a declining trend in the yield of both the crops was observed under this treatment. Moreover, high amount of rainfall had yield depressing effect on sorghum and wheat and increased number of fallow days adversely affected the sorghum yield. The number of irrigations had positive effect on the yield of wheat crop.

Key words : Long-term experiment, integrated nutrient management, sorghum-wheat sequence, fertilizer, manure.

Long-term experiments provide useful information for sustainability of crop yield and management of soil health. Jenkinson (1991) on the basis of data from a Rothamsted long-term experiment showed that grain yield can be sustained (and even increased) for almost 150 years in mono-culture of wheat and barley by using organic and inorganic fertilizers. Jenkinson *et al.* (1994) analyzed yield data of selected plots from the Rothamsted long-term continuous hay experiments to see if any long-term trends could be deducted over the last 10 years. They observed mixed results. Dyke (1988) studied changes in crop yields over time in a long-term experiment conducted at Rothamsted Experimental Station. To study the effect of continuous application of manure and fertilizers to the same plots, Sen and Kavitkar (1956) analyzed data from a Permanent Manurial Experiment conducted at Pusa, Bihar during 1932-1952. Narain *et al.* (1990) examined the trends in yield over years, nutrient uptake by crops and changes in soil fertility. Here, we study the effect of fertilizer treatment and organic manure on the yield of crops from a long-term experiment on sorghum-wheat sequence conducted on fixed plots at Akola centre. We also examine whether the yield of crops exhibit long-term trend over the years.

MATERIALS AND METHODS

A long-term experiment on integrated nutrient supply system on cereal-based crop sequences was conducted by the Project Directorate for Cropping Systems Research, Modipuram on different research centres. Here, we have carried out the analysis of the data of the experiment conducted during the period 1984-85 to 2002-03 using the most prevalent crop sequence of the region, *viz.*, sorghum-wheat. In this experiment, 12 treatments of fertilizers in combination with organic manures were tried in randomized complete block design with 4 replications. The randomization was carried out in the first year of the experimentation and the same arrangement was continued in the subsequent years. Varieties CSH-9 for sorghum and HD-2189 for wheat were used thoughout the period of experimentation. Fertilizer treatment consisted of two component, one component was applied to the *kharif*, sorghum and the other to the *rabi* wheat. The same treatments was repeated every year on the same plot and the observations were recorded. The description of the treatments is as follows :

T_1 : no fertilizer (control) in *kharif* and *rabi;* T_2 : 50% recommended NPK through fertilizers in *kharif* and *rabi* ; T_3 : 50 and 100% recommended NPK through fertilizers in *kharif* and *rabi,* respectively; T_4 : 75% recommended NPK through fertilizers in *kharif* and *rabi;* T_5 : 100% recommended NPK through fertilizers in *kharif* and *rabi* ; T_6 : 50% recommended NPK through fertilizers + 50% N through FYM in *kharif* and 100% recommended NPK through fertilizers in *rabi;* T_7: 75% recommended NPK through fertilizers in both the seasons and 25% N through FYM in *kharif* only ; T_8 : 50% recommended NPK through fertilizers +50% N through crop residues in *kharif* and 100% recommended NPK through fertilizers in *rabi;* T_9 : 75% recommended NPK through fertilizers in both the seasons and 25% N through crop residues in *kharif* only ; T_{10} : 50% recommended NPK through fertilizers + 50% N through green manure in *kharif* and 100% recommended NPK through fertilizers in *rabi* ; T_{11} : 75% recommended NPK through fertilizers in both the seasons and 25% N through green manure in *kharif* only; T_{12} : Farmers' practice in both the seasons which included (50 N-25P) in *kharif* and (40N-25P-12.5K) in *rabi.*

(FYM stands for farmyard manure and the recommended dose of N-P-K fertilizers for sorghum was 100-60-60 and for wheat, 120-60-60.)

Analysis of variance as described below was used to study the effect of fertilizer and organic manure on the yield of crops.

Analysis of variance

Let y_{hij} be the yield of the plot receiving i-th fertilizer treatment in j-th replication during h-th year. We consider the following linear fixed effect model :

$$y_{hij} = \mu+\pi_h+\iota_i+\beta_j+\gamma_{hi}+\delta_{hj}+\alpha_{ij}+\varepsilon_{hij},$$

$$h=1,2..., p\ (\geq 2)\ ;\ i = 1, 2, ..., v; j =1,2...,r \qquad (1)$$

μ is the general mean, π_h is the effect of the h-th year (here year effect has been treated as fixed), ι_i is the effect of i-th treatment, β_j is the effect of j-th replication, γ_{hi} is the year x treatment interaction effect, δ_{hj} is the year x replication interaction effect, α_{ij} is the treatment x replication effect and ε_{hij} are the random errors assumed to be identically independently distributed normally with mean zero and constant variance, σ^2. Application of least squares method gives the estimate of elementary contrast between two treatment effects

$\hat{\tau}_i$ and $\hat{\tau}_m$ as $\hat{\tau}_i - \hat{\tau}_m = \bar{y}_{.i.} - \bar{y}_{.m.}$,

with $\bar{y}_{.i.} = \sum_h \sum_j y_{hij} / pr.$ The variance of this contrast is

$$V\ (\hat{\tau}_i - \hat{\tau}_m) = 2\sigma^2/pr\ ;\ i \neq m \qquad (2)$$

Under the model (1), it can be seen (by taking expected value of each mean square) that the error mean square is the appropriate divisor in the F-test for testing the significance of variation due to various sources included in Table 1. Besides, the error mean is an unbiased estimator of the error variance which can be used in (2) to obtain unbiased estimate of the variance of elementary contrast between treatment effects. The partitioning of the total sum of squares into various components is given in Table 1.

Regression Analysis

To examine whether the yield exhibited long-term trends over the years, regression analysis was carried out by taking yield for each treatment averaged over replications as the dependent variable and explanatory variables such as amount of rainfall during the crop season, number of fallow days before the sowing of the crop, and number of irrigations. A suitable polynomial of time trend was also included in the model.

RESULTS AND DISCUSSION

Effect of fertilizer treatments on crop yields

The analysis of variance carried out on the yield of both the crops showed that treatment, year and replication effects were statistically significant at 1% level and so were the two-factor interaction effects year x treatment and year x

Table 1. Partitioning of total sum of squares into various components

Source	d.f.	Sum of squares
Years (Y)	p-1	$vr\sum_{h}(\bar{y}_{h..}-\bar{y}_{...})^2$
Treatments (Tr)	v-1	$pr\sum_{i}(\bar{y}_{.i.}-\bar{y}_{...})^2$
Replications (R)	r-1	$pv\sum_{j}(\bar{y}_{.j.}-\bar{y}_{...})^2$
Y x R	(p-1) (r-1)	$v\sum_{h}\sum_{j}(\bar{y}_{h.j.}-\bar{y}_{h..}-\bar{y}_{..j}+\bar{y}_{...})^2$
Y x Tr	(p-1) (v-1)	$r\sum_{h}\sum_{i}(\bar{y}_{hi.}-\bar{y}_{h..}-\bar{y}_{.i.}+\bar{y}_{...})^2$
Tr x R	(v-1) (r-1)	$p\sum_{i}\sum_{j}(\bar{y}_{.ij}-\bar{y}_{.i.}-\bar{y}_{..j}+\bar{y}_{...})^2$
Error	(p-1) (v-1) (r-1)	ESS
Total	pvr-1	$\sum_{h}\sum_{i}\sum_{j}(\bar{y}_{hij}-\bar{y}_{...})^2$

Here, ESS =

$$\sum_{h}\sum_{i}\sum_{j}(y_{hij}-\bar{y}_{hi.}-\bar{y}_{h.j}-\bar{y}_{.ij}+\bar{y}_{h..}+\bar{y}_{.i.}+\bar{y}_{..j})^2$$

with $\bar{y}_{...}=\sum_{h}\sum_{i}\sum_{j}y_{hij}/pvr,\ \bar{y}_{h..}=\sum_{i}\sum_{j}y_{hij}/vr,\ \bar{y}_{..j}$

$$=\sum_{h}\sum_{i}y_{hij}/pv,\ \bar{y}_{hi.}=\sum_{j}y_{hij}/r, \bar{y}h.j\ ,$$

$\bar{y}_{h.j}=\sum_{i}y_{hij}/v$, and $\bar{y}_{.ij}=\sum_{h}y_{hij}/p$

replication for both the crops (Table 2). The lowest yield for both the crops under treatment T1 (control) Table 3. Treatment T5, gave the highest grain yield of sorghum (31.97 q/ha) which is not significantly different from the yield obtained from the application of treatment T6 ; the sorghum yield being 31.80 q/ha under treatment T6. In case of wheat, the maximum yield of 29.13 q/ha was realized from application of treatment T6 followed by the yield from treatment T5 (27.93 q/ha) which was significantly lower than the yield obtained from treatment T6. Therefore, considering the performance of

Table 2. Analysis of variance for sorghum and wheat yield

Source	DF	Sorghum			Wheat		
		SS	MS	F	SS	MS	F
Year (Y)	18	62776.11	3487.56	399.19*	53817.06	2989.84	470.31*
Treat (Tr)	11	46707.40	4246.13	486.01*	42641.81	3876.53	609.79*
Rep (R)	3	502.71	167.57	19.18*	356.15	118.72	18.67*
Y x R	54	1407.73	26.07	2.98*	968.45	17.93	2.82*
Y x Tr	198	15012.92	75.82	8.68*	9482.92	47.89	7.53*
Tr x R	33	452.88	13.72	1.57	247.99	7.51	1.18
Error	594	5189.57	8.74		3776.12	6.36	
Total	911						

*Significant at 1% level

Table 3. Treatment-wise mean yields (q/ha) for sorghum and wheat

	$\bar{y}_{.1.}$	$\bar{y}_{.2.}$	$\bar{y}_{.3.}$	$\bar{y}_{.4.}$	$\bar{y}_{.5.}$	$\bar{y}_{.6.}$	$\bar{y}_{.7.}$	$\bar{y}_{.8.}$	$\bar{y}_{.9.}$	$\bar{y}_{.10.}$	$\bar{y}_{.11.}$	$\bar{y}_{.12.}$
Sorghum	4.86	23.64	25.13	27.58	31.97	31.80	30.95	26.30	27.07	30.72	29.69	20.68
Wheat	4.10	18.84	25.21	23.72	27.93	29.13	26.10	26.56	24.34	27.80	25.99	15.02

C.D. *for sorghum at 1%=1.2354 and at 5%=0.9400;* C.D. *for wheat at 1%=1.0538 and at 5%=0.8018*

all the treatments on both the crops together, treatment T6, i.e. application of (50-30-30 : N-P-K kg/ha) with 10 tonnes FYM/ha during *kharif* and recommended dose (120-60-60 : N-P-K kg/ha) during *rabi* appeared to be the most appropriate choice in obtaining the highest grain yield of the sequence.

Besides, the treatments T6, T5, T10, and T8 were all found to be significantly different from each other in giving yields of both the crops together and ranked first, second, third and fourth, respectively. The sorghum and wheat yields (q/ha) under these treatments were found to be respectively 31.80 and 29.13 for T6, 31.97 and 27.93 for T5, 30.72 and 27.80 for T10, and 26.30 and 26.56 for treatment T8 (Table 3). Furthermore, the respective yields (q/ha) of sorghum and wheat were 30.95 amd 26.10 for treatment T7, 29.69 and 25.99 for treatment T11, and 27.07 and 24.34 for treatment T9.

Effect of additional 50% N equivalent of recommended dose through organic manures applied with 50% recommended NPK through fertilizers to sorghum

A comparison of yield of sorghum and wheat under treatments T6, T8 and T10 with that of treatment T3 indicated the effect of additional 50% N eqivalent of recommended dose applied through farmyard manure or crop residues or green manure, respectively with 50% recommended NPK dose through fertilizers in *kharif* followed by 100% recommended NPK through fertilizers in *rabi*. The results revealed that the increase in yield of both the crops was highest in the case of farmyard manure (6.67 q/ha for sorghum and 3.92 q/ha for wheat) followed by green manure (5.59 q/ha for sorghum and 2.59 q/ha for wheat) and crop residues (1.17 q/ha for sorghum and 1.35 q/ha for wheat), respectively.

Effect of additional 25% N equivalent of recommended dose through organic manures applied with 75% recommended NPK through fertilizers to sorghum

A comparison of yield from treatments T7, T9 and T11 with that from treatment T4 containing 75% recommended dose through fertilizers in both the seasons gave information on the effect of additional 25% N equivalent of recommended fertilizer dose applied to sorghum in *kharif* season through various types of organic manures. Application of farmyard manure increased the yield of sorghum by 3.37 q/ha and that of wheat by 2.38 q/ha. The application of green manure increased the yield of sorghum and wheat by 2.11 and 2.27 q/ha, respectively. The application of additional 25% N equivalent of recommended fertilizer dose through crop residues had no significant effect on the yield of both the crops.

Effect of additioal 50% recommended NPK dose through fertilizers applied to wheat crop

Treatment T2 comprised of application of 50% recommended NPK through fertilizers to each of the crops i.e., sorghum in *kharif* and wheat in *rabi*, whereas the treatment T3 contained 50% recommended NPK through fertilizers in *kharif* and 100% recommended NPK through fertilizers in *rabi*. A comparison of yield from treatment T3 with that from treatment T2 revealed that the application of additional 50% recommended NPK dose to wheat not only increased the yield of wheat by 6.37 q/ha over the yield obtained under 50% recommended NPK dose but also increased the yield of sorghum by 1.49 q/ha. Thus, increase in yield of the sorghum was the effect of carry over fertilizers from wheat to sorghum crop.

Effect of different levels of recommended fertilizer dose

The treatments T2, T4 and T5 contained, respectively 50, 75 and 100% recommended NPK dose, through fertilizers in both the seasons. The responses of sorghum at T4 over T2, and T5 over

Table 4. Estimated yield equations for sorghum and wheat

	R^2	Intercept	t	t^2	Rf	Fl	R^2	Intercept	t	t^3	Rf	Rf^2 (x 10^{-4})	Ir
T1	.79	21.958*	-2.127*	-0.078*	-0.008*	-0.013	.34	-1.872		-0.009***	0.011	-0.40	1.215**
		(5.777)	(0.460)	(0.023)	(0.003)	(0.044)		(2.111)		(0.004)	(0.013)	(0.30)	(0.540)
T2	.44	62.687*	-0.527**		-0.016**	-0.266**	.67	-2.453	0.544*		0.099*	-3.00*	1.457*
		(13.198)	(0.246)		(0.006)	(0.0101)		(4.003)	(0.163)		(0.035)	(0.90)	(0.507)
T3	.62	71.109*		-0.038*	-0.023*	-0.292*	.53	0.338	0.476		0.112**	-0.400**	1.873**
		(11.323)		(0.011)	(0.006)	(0.088)		(6.167)	(0.261)		(0.054)	(1.50)	(0.782)
T4	.55	66.369*	2.160***	-0.134**	-0.025*	-0.296*	.71	-13.064**		-0.053*	0.091**	-3.00*	7.174*
		(13.636)	(1.086)	(0.055)	(0.008)	(0.105)		(6.253)		(0.015)	(0.038)	(1.00)	(1.602)
T5	.59	71.577*	3.061**	-0.187*	-0.029*	-0.311**	.63	-17.305***		-0.0059*	0.151*	-4.00*	8.323*
		(14.607)	(1.163)	(0.059)	(0.008)	(0.113)		(9.427)		(0.021)	(0.057)	(2.00)	(2.416)
T6	.63	74.277*	3.242*	-0.188*	-0.032*	-0.333*	.62	-18.272***		-0.068*	0.158**	-5.00*	9.049**
		(14.147)	(1.126)	(0.057)	(0.008)	(0.109)		(9.922)		(0.023)	(0.060)	(2.00)	(2.542)
T7	.54	70.202	3.340**	-0.195*	-0.028*	-0326**	.71	-16.970**		-0.057*	0.152*	-4.40*	7.931*
		(16.536)	(1.317)	(0.067)	(0.009)	(0.127)		(7.701)		(0.018)	(0.047)	(1.30)	(1.973)
T8	.39	62.415*	1.399	-0.081	-0.020**	-0.298**	.69	-17.030**		-0.062*	0.142*	-4.10*	8.291*
		(15.884)	(1.265)	(0.064)	(0.009)	(0.122)		(7.801)		(0.018)	(0.047)	(1.00)	(1.999)
T9	.40	57.090*	1.955***	-0.115***	-0.020**	-0.251**	.61	-12.927		-0.055*	0.111**	-3.00**	7.187*
		(14.809)	(1.179)	(0.060)	(0.008)	(0.114)		(7.736)		(0.018)	(0.047)	(1.00)	(1.982)
T10	.66	70.021*	4.458*	-0.243*	-0.034*	-0.336*	.64	-22.275**		-0.071*	0.170*	-5.00*	9.564*
		(14.641)	(1.166)	(0.059)	(0.008)	(0.113)		(10.102)		(0.023)	(0.061)	(2.00)	(2.588)
T11	.50	60.769*	3.631*	-0.198*	-0.026*	-0.285**	.66	-14.761***		-0.052*	0.144*	-4.10*	7.380*
		(16.711)	(1.331)	(0.068)	(0.009)	(0.129)		(7.989)		(0.018)	(0.048)	(1.00)	(2.047)
T12	.51	52.783*	-0.481**		-0.016*	-0.192**	.54	-5.276		-0.031*	0.066**	-2.00**	3.879*
		(10.301)	(0.192)		(0.005)	(0.079)		(4.856)		(0.011)	(0.029)	(1.24)	(.00001)

Note: 1. t-Trend variable; Rf-Amount of rainfall during the crop season (mm); Fl-Number of fallow days before sowing of crop; Ir-Number of irrigations. Figures in parentheses indicate the standard errors.
2.*Significant at 1%**Significant at 5%; ***Singnificant at 10%.
3. Results are given in the order, sorghum and wheat.

T4 were 3.94 and 4.39 q/ha, respectively (Table 3). These responses for wheat crop were 4.88 and 4.21 q/ha, respectively. That is, as the level of NPK dose increased the response of sorghum increased, whereas the response of wheat decreased.

Long-term treands in yield

The yield data averaged over the replications for each treatment were examined for the long-term trends over the year for both the crops of the sequence. Besides trend variables, amount of rainfall during the crop season, number of fallow days before the sowing of crop and number of irrigations were also included in the regression equations. Treatment-wise yield equations have been presented in Table 4, shows that the yield of both sorghum and wheat under all the treatments except T2 and T3 exhibited a declining trend over the years. However, the rate of decline varied from treatment to treatment. The yield of sorghum crop also showed a declining tendency under both the treatments T2 and T3 whereas the wheat yield remained stagnant over years under treatment T3 and had an increasing trend under treatment T2. The increasing trend in the yield of wheat under T2 could be due to usage of suboptiomal dose of NPK fertilizers. Furthermore, the data also shows that the incrased amount of rainfall had adverse effect on the yield of both the crops under all the treatments and increased number of fallow days adversely affected the sorghum yield (the average number of of fallow days available for sorghum was 104). The number of irrigations had positive effect on the yield of wheat for all the treatments.

Conclusion

The analysis revealed that the treatment with 50% recommended NPK dose through fertilizers with 50% N through farmyard manure in *kharif* and 100% recommended NPK dose through fertilizers in *rabi* gave the highest grain yield of both the crops together at the Akola centre. However, a declining trend in the yield of both the crops was observed under this treatment.

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IMPACT OF NUTRITION ON GROWTH AND INSECT INFESTATIONS ON KAGZI LIME IN RESPECT OF MANAGEMENT OF CITRUS DECLINE

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ABSTRACT

Different combinations of macro-nutrients were applied, viz, T1 (Control) - zero doses of nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O); T2 – 125 g N, 30 g P_2O_5 and 70 g K_2O per year per plant, T3 (optimum doses) – 150 g N, 40 g P_2O_5 and 80 g K_2O per tree per year, and T4 – 175 g N, 50 g P_2O_5, and 90 g K_2O per year. Till the second years of plant age, growth was not affected significantly by nutrition, indicating adequate availability of these nutrients in the soil. However, in the third year, macro-nutrients had significant effect on plant growth. Differences in plant height between T1 and T2/T3 T4 were significant, i.e., all nutrient combinations showed significantly higher plant height over the control. Differences in collar diameter between T1 and T4, and between T2 and T4 were significant. Micronutrient application increased collar diameter significantly. The highest incidence of citrus leaf miner (*Phyllocnistis citrinell* Sta.) was observed on the plants under T4 whereas the incidence was lowest (29.76%) in T1. Average population of aphids was maximum in December-January, while the minimum was in March to May. The incidence of CTV or citrus decline was not visible in any of the treatment combinations.

Key world : Citrus decline, Kagzi lime, plant nutrition, citrus leaf miner.

The incidence of citrus decline has the most devastating impact on citrus plantation throughout the world. Poor nutritional status of soil nad malnutrition, along with Citrus Tristeza Virus (CTV) and greeting bacterium (*Liberobactor asiaticum*) are being recognized as the most potent causes for citrus decline in India. It is estimated that the total world damage amounts to about 50 million tree lost or unproductive as a result of CTV, while in India, estimates indicated that CTV destroyed one million trees. It is generally agreed that the problem of citrus decline can be best managed by an integrated approach of using virus free planting material, use of host resistance, sanitation, cultural practices, vector control and regulatory measures (Sharma and Singh, 2003). The incidence of citrus decline can be avoided or delayed by keeping the plant healthy by providing them adequate nutrition. The response of fertilizers in improving the growth, yield and quality of different citrus fruits is well recognized under different agro-climatic regions of the country (Ghosh, (1990); Kumar *et al.* (1993); Raj Kumar *et al.*, (1998); Ram *et al.*, (1997); and Singh *et al.*, (2003). Mishra *et al.* (2003) observed improvement of yield and fruit quality in Kinnow by the foliar spray of micronutrient (boron and zinc). In western Maharastra, no systematic studies have been conducted to work-out optimal nutritional requirement of Kagzi lime, and their impact of nutrition on growth and insect infestation with the aim of reducing damages by citrus decline in Kagzi lime.

MATERIALS AND METHODS

The experiment was carried out from 2001 to 2003 on CTV free Kagzi lime (*Citrus aurantifolia* (Christm.) Swing.) planted in July 2000 at Research Farm, IARI, Regional Station, Pune. Plant growth (height and collar diameter) of all plants under experimentation was statistically at par at the beginning of the experiment in 2001 (Table 2). The experimental site had black cotton soil (vertisol) with low infiltration. Chemical properties and nutritional value of the soil are given in Table 1. The following combinations of nitrogen (N), phosphorus (P) and potassium (K)

Table 1. Chemical properties and nutritional values of the soil

Property/Nutrient	Range
pH	6.8-7.08
EC (ds/m 1:2)	0.868-1.800
OC (%)	0.15-0.39
P (Kg/Ha)	10.4-22.1
K (Kg/Ha)	425-500
Ca (ppm)	6385-7257
Mg (ppm)	17371865
Na (ppm)	450-475
C1 (ppm)	62-133
Zn (ppm)	1.04-1.16
Fe (ppm)	3.56-12.36
Cu (ppm)	4.34-9.00
Mn (ppm)	189-416

were applied to plants for three years (2001 to 2003) to ascertain the optimum requirement of N,P and K for Kagzi lime during the initial growth period. :

Treatment combinations

T1— Treatment 1 (N0 P0 K0: fertilizer, Control

T2— Treatment 2 (N1 P1 K1: 125 g N, 30 g P_2O_5 and 70 g K_2O/plant/year of age)

T3— Treatment 3 (N2 P2 K2: 150g N, 40 g P_20_5 and 80 g K_2O/plant/year of age), optimum doses for nearby area

T4— Treatment 4 (N3 P3 K3: 175 g N, 50g P_20_5 and 90 g K_2O/plant/year of age)

Nitrogen was applied in two split doses in early season and spring season, whole P and K was applied along with first dose of N. Standard doses of micronutrient like boron (B), copper Cu), iron (Fe), manganese (Mn) and zinc (Zn) were provided through foliar spray once in year to each treatment combination and compared with control by maintaining the other set of treatment combinations without micronutrient application.

Soil and leaf samples for nutrient analysis were collected following standard procedure. Nitrogen, P and K were measured by alkaline per magnate method, Olsen's method and ammonium acetate extract method by flame photometer respectively in soil, while in plant tissues, N, P and K content were determined by Micro-kjeldahl distillation, Vandomolybdate yellow colour and flame photometer methods respectively. Calcium, Mg and micronutrients were estimated by atomic absorption spectrophotometer. Growth data (plant height and collar diameter) was recorded at the time of experiment, and for subsequent years (2002 and 2003) after rainy season. Experimental design of Factorial RBD with three replications, and nine plant units under each replication was applied using standard methods of statistical analysis.

RESULTS AND DISCUSSION

Till the second year of plant age, plant height

Table 2. Effect of nutrition on plant growth in the 1st and 2nd year of age (2001 and 2002)

Plant height

	T1		T2		T3		T4	
	2001	2002	2001	2002	2001	2002	2001	2002
Mo	75.74	176.91	82.56	181.06	82.81	184.31	82.52	195.69
M1	81.52	194.86	86.26	171.26	71.78	146.62	79.81	158.47

Collar diameter

	T1		T2		T3		T4	
	2001	2002	2001	2002	2001	2002	2001	2003
Mo	1.10	3.55	1.05	4.15	0.99	3.35	1.06	3.94
M1	1.11	3.17	1.08	3.23	1.01	3.05	1.08	3.85

Note : The differences between plant height and coller diameter within a year and between various nutrient combnations were statistically non-significant.

Table 3. Effect of nutrition on plant growth in the 3rd year (2003)

Plant height	T1	T2	T3	T4	Mean	CD at 5%
Mo	192.50	202.92	213.33	216.25	206.25	
M1	188.75	205.83	215.42	218.33	207.08	
Mean	190.63	204.38	214.38	217.29	206.67	
C.D. at 5%	NS	NS	NS	NS		9.33
Coller diameter						
Mo	5.18	5.57	5.63	6.33	5.68	
M1	5.58	6.01	6.33	6.49		
Mean	5.38	5.79	5.98	6.39	5.89	0.799
C.D. at 5%	NS	NS	NS	NS	0.398	

and collar diameter was not affected significantly by various nutritional combinations (Table 2), indicating adequate availability of these nutrients in the soil. However, in the third year, macronutrients had significant effect on plant growth. Differences in plant height between T1 and T2 and T4 was significant. Micronutrient application increased collar diameter significantly. Plant tissue concentration of NPK and other micronutrients, indicated that plant were deficient in N and Ca, excess in Na, Fe and Mn, while P, Mg, Cu and Zn were in moderate quantity (Table 4). There was no clear cut pattern of plant tissue nutrient content with various treatment combinations.

The increase in the growth of trees with the application of N might be due to the increased accumulation of proteins, nucleic acid, nucleotides and enzymes. The increased uptake of N and P is expected to increase the rate of growth.

Improvement in growth parameters of citrus species by N application had been reported by earlier workers also (Ghosh, (1990); Kumar *et al.*, (1993) and Monga et al., (2002). Govind and Singh (2003) found maximum increase in shoot growth in terms of plant height with spay of N followed by P in Khasi mandarin. They observed that N and P are beneficial in enhancing growth during initial stage of plant growth. Monga *et al.*, (2002) observed that tree volume and stock/scion girth increased with the application of N alone@ 300 to 900 g/tree over control. Application of 900 g N, 300 g P and 300 g K was found to be the best dose combination for higher fruit yield and better quality in sweet orange cv. Jaffa. Raj Kumar *et al.*, 1998) reported that fruit yield in Kinnow increased with increasing doses on N and P. Sinnificant increased in growth and yield with nitrogenous fertilizers was reported in Kinnow mandarin (Ravikumar *et al.*, 1993) and Valentia orange (Sarooshi *et al.*, (1991)). Huchche *et al.*, (1996) observed that there was significant increase in growth, yield and quality of eight years old acid lime plants. There was significant increase in growth and yield of acid lime with application of 400 g and 800 g N. Singh and Misra (1985) reported increased yield in Pant Lemon-1 with increasing level of N.

The highest incidence of citrus leaf miner (*Phyllocnistis citrinella* Sta.) was observed on the plants under T4, whereas the incidence was

Table 4. Effect of soil application of nutrients (N,P & K) and foliar application of micronutrients (B, Cu, Fe, Mn & Zn) on the plant nutritional status

Nutrient	T1	T2	T3	T4
N(%)	1.65	2.00	1.84	1.75
P(%)	0.196	0.157	0.141	0.127
K(%)	1.50	1.55	1.33	1.33
Ca(%)	1.98	2.15	2.26	2.50
Mg(%)	0.25	0.27	0.26	0.28
Na(%)	0.24	0.25	0.23	0.23
Cu (ppm)	7	9	9	7
Zn (ppm)	12	11	10	8
Fe (ppm)	46	69	98	73
Mn (ppm)	59	70	68	80

lowest (29.76%) in the control, indicated that the higher amount of nutrition give rise to enhanced new growth that encouraged higher incidence of leaf miner. Average population of aphids, a potent vector of CTV, was maximum in December-January, with another peak in June-July. The aphid population was minimum in March to May. The incidence of CTV or citrus decline was not visible in any of the treatment combinations :

Where :

T1 (Control)—No fertilizer application
T2 125 g Nitrogen (N), 30 Phosphorus (P_2O_5) and 70 g Potassium (K_2O) year/plant
T3 (recommended doses)—150 g N, 40g P_2O_5 and 80 g K_2O/year/plant
T4 175 g N, 50 g P2O5, and 90 g K2O year/plant
Mo No application of micronutrients
M1 Application of standard doses of micronutrients (boron, copper, iron, manganese and zinc) through foliar spray

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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON PRODUCTIVITY, QUALITY AND NUTRIENT UPTAKE BY INDIAN MUSTARD AND THEIR RESIDUAL EFFECT ON PIGEONPEA

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ABSTRACT

A field experiment was conducted during *rabi* and *kharif* seasons of 2002-03 and 2003-04 on nutrient management aspect of mustard-pigeonpea sequence at New Delhi. The application of RDF to mustard produced significantly higher seed and stover yield of mustard. However, it remained on par with half RDF + PSB + *Pruteus vulgaris*. Pigeonpea produced significantly higher grain and stalk with the application of half RDF + PSB + *Pruteus vulgaris* in preceding mustard crop. Oil content in mustard was not influenced by the application of fertilizer nutrients, whereas oil yield was significantly higher with the application of half RDF +PSB + *Pruteus vulgaris* over control, half RDF and 40 kg N/ha + PSB. Significantly higher protein content (19.3%) was obtained with the application of RDF over control, half RDF and 40 kg N/ha +PSB, whereas it remained on par with half RDF + PSB + *Pruteus vulgaris*. The higher removal of N and P by mustard was recorded with the application RDF over control, half RDF and 40 kg N/ha + PSB, but it remained on par with half RDF + PSB + *Pruteus vulgaris*. Pigeonpea removed significantly higher N and P from the application of half RDF + PSB + *Pruteus vulgaris* in preceding mustard crop.

Key words : Integrated nutrient management, quality, Indian mustard, pigeonpea, nutrient uptake.

Indian mustard (*Brassica jumcea*) occupies about 80 per cent of area under rapeseed-mustard group and widely grown in Rajasthan, Haryana, Punjab and Uttar Pradesh under limited irrigation. Amongst the oilseeds, rapeseed-mustard (*Brassica* spp.) is the third largest indigenous oilseed crop after groundnut and soybean. The greatest limitation for increase in productivity of these crops is inadequate supply of fertilizer nutrients. The proper application of fertilizer nutrients may increase the production and productivity of these crops, therefore, application of N, P with bio fertilizers and their judicious combination is required to utilize nutrients efficiently for long term sustainability. Keeping these points in view, the present investigation was taken to find out the optimum combination of different nutrients and their effect on mustard-pigeonpea sequence.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* and *kharif* seasons of 2002-03and 2003-04 on nutrient management aspect of mustard-pigeonpea sequence at the research farm of Division of Agronomy, Indian Agricultural Research Institute, New Delhi. Treatments consisting five levels of nutrient management [control, half RDF, RDF (80 kg N + 40 kg P_2O_5/ha), 40 kg N + PSB and half RDF + PSB + *Pruteus vulgaris*] were imposed on mustard. The experiment was conducted on randomized block design with nine replications. The soil of the experimental site was sandy loam having 157.2 kg available N/ha, 20.4 kg P/ha and 231.7 kg K/ha pH 7.1. The mustard crop was sown in the last week of October during both the seasons at a row to row spacing of 40 cm. The seeds of mustard were inoculated with phosphorus solubilizing bacteria and *Pruteus vulgaris* as per the treatments. Nitrogen was applied through urea in two splits, one half as basal dose and half at 40 days after sowing. Phosphorus was applied through single super phosphate below the seed at the time of sowing as per treatments.

Table 1. Effect of integrated nutrient management of productivity and quality of mustard and their residual effect on pigeonpea (pooled data of 2002-03 and 2003-04)

Treatment	Yield (t/ha)				Quality parameters of mustard		
	Mustard		Pigeonpea		Oil content(%)	Oil yield (kg/ha)	Protein (kg/ha)
	Seed	Stover	Grain	Stalk			
Control	1.054	3.164	1.48	6.31	38.2	402	16.5
50% RDF	1.523	3.976	1.70	7.25	37.0	564	17.7
RDF (80 kg N+40 kg P_2O_5/ha)	1.784	4.494	1.93	8.03	36.3	647	19.3
40 kg N/ha + PSB	1.500	3.968	1.67	7.17	38.0	570	17.6
50% RDF + PSB + *Pruteus vulgaris*	1.753	4.474	1.98	8.11	37.3	654	18.8
CD (P=0.05)	0.216	0.380	0.18	0.82	NS	52	0.9

Table 2. Effect of integrated nutrient management on N and P uptake in mustard and their residual effect on pigeonpea (pooled data of 2002-03 and 2003-04)

Treatment	N uptake (kg/ha)						P uptake (kg/ha)					
	Mustard			Pigeonpea			Mustard			Pigeonpea		
	Seed	Stover	Total	Grain	Stalk	Total	Seed	Stover	Total	Grain	Stalk	Total
Control	27.9	16.3	44.2	37.8	71.2	109.1	5.6	6.4	12.0	4.8	7.4	12.4
50% RDF	43.2	21.9	65.1	46.9	94.6	141.6	8.4	8.6	17.1	5.9	9.4	15.4
RDF (80kg N + 40kg P_2O_5/ha)	55.2	26.4	81.6	55.6	111.7	167.4	10.4	10.4	20.8	7.1	11.5	18.2
40 kg N/ha + PSB	42.2	21.7	63.9	46.2	94.2	140.6	8.3	8.5	16.8	5.8	9.3	15.2
50% RDF + PSB +*Pruteus vulgaris*	52.8	25.9	78.8	58.6	116.4	175.1	10.1	10.2	20.4	7.4	12.0	19.5
CD (P = 0.05)	6.5	3.2	9.6	6.5	13.7	21.4	1.3	1.2	2.6	0.8	1.2	2.1

Oil content was determined by using NMR technique. The nutrient uptake (N and P) was estimated separately for grain and stover and was added to find out the total nutrient uptake.

RESULTS AND DISCUSSION

Effect on yield

Application of RDF produced significantly higher seed and stover yield over control, half RDF and 40 kg N/ha +PSB (Table 1). However, it was on par with half RDF + PSB + *Pruteus vulgaris*. Thus application of RDF produced highest seed (1.784 t/ha) and stover (4.494 t/ha) yield, which was 69 and 42 per cent higher, respectively over control. This might be due to the fact that more photosynthates were trnslocated from source to sink and resulted in the highest yield with RDF. Similar results were also reported by Punia *et al.* (2002). Among the preceding treatments half RDF +PSB + *Pruteus vulgaris* recorded the highest grain (1.98 t/ha) and stalk (8.11 t/ha) yield followed by RDF applied to mustard. The increase in grain and stalk yield of pigeonpea due to preceding half RDF +PSB + *Pruteus vulgaris* were 33 and 28 per cent, respectively over control. This might be due to the residual effect of bio fertilizer to solubilize the nutrients and increase their availability for succeeding crop. Similar results were also reported by Tiwari *et al.* (2000).

Effect on quality parameters

Nutrient application suppressed the oil content of mustard. However, differences among various levels of nutrient management were not significant. The highest oil (654 kg/ha) content was produced when mustard was fertilized with half RDF + PSB + *Pruteus vulgaris*. However, it remained statistically on par with RDF. The increase in oil productivity due to half RDF + PSB + *Pruteus vulgaris* was 62 per cent over control. Protein content in seed was significantly higher by the application of RDF over control, half RDF and 40 kg N/ha + PSB. Protein content with the application of RDF + PSB + *Pruteus vulgaris* was found to be non significant. The decrease in oil content was because of the fact that higher availability of nutrients suppresses the oil synthesis. This might be due to degradation of carbohydrates to acetyl CoA in tricarboxylic acid (TCA) cycle. Seed inoculation with PSB increased the uptake of N by seed and ultimately protein content. Similar result was also reported by Nanwal *et al.* (2000).

Effect on total N and P uptake

The highest removal of N and P by mustard was recorded when it was fertilized with RDF (Table 2). The per cent increase in N and P uptake due to RDF was 84 and 73, respectively over control. However, application of RDF and half RDF + PSB + *Pruteua vulgaris* removed statistically similar amount of N and P by mustard. This might be due to application of N and P with PSB and *Pruteus vulgaris* by virtue of their role in root development. The increased availability of N and P with increased N and P content in both seed and stover and resulted in more uptake of N and P. Similar findings were also reported by Rana *et al.* (2002).

The highest N and P uptake by pigeonpea was recorded when the crop was raised after half RDF + PSB + *Pruteus vulgaris* as preceding treatments in mustard crop. This might be due to improved availability of nutrients to pigeonpea plant. Similar findings were also reported by Shivran *et al.* (2001).

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EFFECT OF IRRIGATION ON GROWTH, YIELD AND MOISTURE USE BY INDIAN MUSTARD (*BRASSICA JUNCEA*)

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Abstract

The present study was carried out during *rabi* seasons of 2003-04 and 2004-2005 to find out the effect of irrigation on growth, yield and moisture use by Indian mustard. The results revealed that application of two irrigations at 45 and 90 days after sowing (DAS) significantly increased plant height, number of primary and secondary branches/plant, siliquae/plant, length of siliqua, number of seed/siliqua, 1000-seed weight, seed yield, straw yield, total biomass and oil yield over one irrigation (at 45 DAS), which in turn, resulted a significant increase in above mentioned parameters over no irrigation in both the years of study. Seasonal consumptive use of water by the crop increased progressively with the increase in number of irrigations, whereas, water use efficiency of crop increased up to one irrigation.

Key words : Irrigation, Indian mustard, seed yield, oil yield, consumptive use, water use efficiency.

Oil and fats occupy an important place in human life. They are not only rich sources of energy and carriers of fat soluble vitamins A, D, E and K but are also the major sources of raw materials for a wide range of industrial products. Of the nine annual oilseed crops grown in the country, rapeseed and mustard assume significance in the national economy occupying third position in area and production next to groundnut and soybean. Of the several reasons for low productivity of mustard as compared to world average, unavailability of adequate irrigation is the most important one. Irrigation increases productivity as is evident from the research results available from different parts of the country. However, information on how many irrigations are required for higher yield is meager, hence a field experiment was conducted to find out optimum water requirement of Indian mustard.

Materials and Methods

The experiment was laid out in split plot design with three replications. The treatments consisted of three levels of irrigation no irrigation, one irrigation at 45 days after sowing and two irrigations at 45 and 90 DAS in main plots and six combinations of three levels (15, 30 and 45 kg S/ha) and two sources (gypsum and cosavet) of sulphur plus a no sulphur control in sub-plots. Since there was no interaction between irrigation and sulphur treatments, the irrigation effects are reported in this paper. The Indian mustard variety Pusa Jagganath was sown on 20th October in 2003-04 and 18th October in 2004-05 with 45 x 15 cm spacing. The soil of the experimental site was sandy loam having 22% clay, 16.5% silt and 61.7% sand and 195.0 kg/ha available N, 11.0 kg available P/ha and 165.0 kg available K/ha and 0.37% organic carbon.

Results and Discussion

Growth and yield attributes

Results indicated that application of two irrigations at 45 and 90 DAS produced significantly taller plant, more number of secondary branches and siliquae/plant, longer siliqua and heavier seeds than one irrigation applied at 45 DAS, which in turn recorded significantly more number of primary branches, seeds/siliqua than no irrigation. The more moisture availability with two irrigations enabled plants to grow better and helped in good translocation of photosynthates from source to

Table 1. Effect of irrigation on growth and yield attributes of mustard

Treatment	Plant height at harvest (cm)	No. of primary branches/plant	No. of secondary branches/ plant	No of siliquea plant	Siliqua length (cm)	No. of seeds/ siliqua	1000-seed weight (g)
			2003-2004				
No irrigation	147.6	5.6	14.5	246.3	3.3	11.0	4.1
One irrigation	168.1	6.8	18.3	368.4	3.8	12.1	5.3
Two irrigations	184.3	7.1	20.3	456.8	4.1	12.7	5.9
C.D. (P=0.05)	9.20	0.40	1.06	26.0	0.27	0.74	0.32
			2004-05				
No irrigation	151.7	5.9	16.2	283.9	3.7	12.3	4.6
One irrigation	172.2	6.8	20.3	409.4	4.2	14.1	5.9
Two irrigations	188.1	7.2	22.6	507.6	4.5	15.0	6.5
C.D. (P=0.05)	10.11	0.51	1.30	28.2	0.24	1.0	0.34

Table 2. Effect of irrigation on seed and straw yiled, oil content and oil yield

Treatment	Seed yield (q/ha)	Straw yield (q/ha)	Oil content (%)	Oil yield (kg/ha)
		2003-2004		
No irrigation	12.8	41.7	34.4	440.3
One irrigation	18.8	52.1	36.2	673.3
Two irrigations	20.6	57.6	38.0	782.8
C.D. (P=0.05)	1.4	3.42	2.27	46.03
		2004-2005		
No irrigation	14.2	46.3	35.5	504.1
One irrigation	20.8	57.9	37.3	775.8
Two irrigations	22.9	63.8	39.1	895.4
C.D. (P=0.05)	1.27	3.33	2.17	50.0

Table 3. Seasonal consumptive use of water and water use efficiency of mustard

Treatment	Seasonal consumptive water use (mm)	Water use efficiency (kg seed/mm ha)
	2003-2004	
No irrigation	166.4	7.7
One irrigation	204.4	9.1
Two irrigations	239.6	8.6
	2004-2005	
No irrigation	177.2	8.0
One irrigation	216.7	9.6
Two irrigations	245.3	9.3

sink, thereby increasing yield attributes namely number of primary and secondary branches/ plant, number of siliqua/plant, length of siliqua, number of seeds/siliqua and 1000-seed weight. Moreover, two irrigations were applied at critical growth stages namely flowering and pod filling which enabled plants to develop better sink. Such results were earlier reported by Singh and Srivastava (1986), Jadhav (1988) and Singh *et al.* (1994).

Seed and straw yield

Results indicated that application of two irrigations at 45 and 90 DAS recorded significantly higher seed and straw yield than one irrigation, which in turn gave higher seed and straw yield than no irrigation. The per cent increase in seed yield due to application of two irrigations were 10.4 over one irrigation and 61.1 over no irrigation. This might be due to better translocation of photosynthates to sink areas along with better nutrient uptake by the crop which resulted into improved yield attributes and ultimately culminated into increased seed yield. The increase in straw yield might be due to increased plant height and more branches/ plant. Further, irrigations at critical stages of crop growth namely flowering and pod filling stages might have helped the plants for increasing yield attributes which ultimately increased seed yield. Similar findings were earlier reported by Singh and Dixit (1989) and Singh *et al.*(1994)

Oil content and oil yield

Results indicated that application of two irrigations at 45 and 90 DAS significantly increased oil yield over one irrigation, whereas, for oil content in seed was not affected by number of irrigations. This might be due to role of irrigation in increasing translocation of mineral nutrients from soil in one hand translocation of photosynthates from leaves (source) to pods (sink) on the other hand, resulting in to higher oil content. Since oil yield is a function of oil content and seed yield, that is why due to increased seed yield and oil content, oil yield is also remarkably increased. Similar findings were earlier reported by Singh and Srivastava (1986), Singh and Dixit (1989) and Bharati *et al.* (2003).

Moisture studies

Results indicated that seasonal consumptive use of water by mustard increased with increasing number of irrigations, whereas water use efficiency increased up to one irrigation (Table 3). The increased consumptive use of water due to application of irrigation might be due to role of irrigation in increasing growth parameters, and yield attributes and for that more water uptake was taken place. The differential response for WUE was mainly due to more increment in seed yield with one irrigation compared to two irrigations. Such results were also reported by Singh *et al.* (1984) and Yadav *et al.* (1999).

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PRODUCTIVITY AND QUALITY OF WHEAT AS INFLUENCED BY TILLAGE, RESIDUE AND NITROGEN MANAGEMENT UNDER RICE-WHEAT CROPPING SYSTEM

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ABSTRACT

Twenty one treatment combinations comprising of seven tillage types clubbed with rice residue management practices and three nitrogen management schedules were evaluated at Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar, for devising suitable tillage and nitrogen management practice for getting sustained productivity and quality of wheat crop under rice-wheat system. They study substantiated that the higher grain as well as protein yield of wheat could be otained by deep incorporation of rice residue either by disc plough or mould-board plough. Retention of residue in field modified the micro-climate suited for crop growth as indicated by canopy temperature depression. Grain growth rate were higher from the residue retention with conservation tillage. (zero and strip). The higher net return was obsurved by burying the rice residues deep. The available soil nitrogen increased by the incorporation/retention of residue irrespective of tillage type. The uptke of nitrogen by the crop followed the same pattern of grain yield. The application of starter dose of 20 kg N/ha at the time of field preparation could be saved by applying 2/3 of recommended dose of nitrogen at basal and rest 1/3 at CRI.

Key words : Rice-wheat, tillage, residue, nitrogen, CTD, protein.

The rice-wheat system got prominence owing to development of photo insensitive and input responsive varieties of both the crop. This system is being followed in 9.8 million ha area in India (Yadav, 1998) and contributes about 80 percent of food grains to the food security system of India. Recently, this cropping system has started showing the signs of resource degradation (Hobbs, 1994). It is mainly due to unscientific tillage practice, development of hard pan, multi-nutritional deficiency and destruction of soil structure. To combat this multi-tired menace, there is a need to devise appropriate tillage technology, management of rice residue coupled with nitrogen management to narrow down the C:N ratio, so that the sustainability of the system could be maintained. The present investigation was conducted for devising suitable tillage and nitrogen management practice for getting sustained productivity and quality of wheat crop under rice-wheat system.

MATERIALS AND METHODS

A field experiment was carried out at Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar during *kharif* and *rabi* seasons of 1999-2000 and 2000-2001. The soil of the experimental field was sility-clay-loam having a pH value of 7.8, high in organic carbon (1.21%) and phosphorus (29 kg/ha), and medium in potassium (240 kg/ha) status. The initial soil bulk density of surface soil was 1.43 Mg/m^3. The experiment was laid out in split-plot design with four replications. The treatments comprised of seven combinations of tillage and rice residue management options and three nitrogen management schedules. The seven treatments of tillage and rice residue management options applied in main plots were; T_1- Straw removal +conventional tillage (6 trailed disc harrow + 1 planker); T_2- Combine harvesting + 1 mould board plough + harrow + 1 planker; T_3-Combine harvesting + 1 standard disc plough + 4 harrow + 1 planker; T_4-Combine harvesting + conventional tillage (6 trailed disc harrow + 1 planker); T_5-Combine harvesting + zero-till-ferti-seed-drill; T_6-Combine harvesting + strip-till-ferti-seed-drill and T_7-Residue burning + conventional tillage (6 trailed disc harrow + 1 planker), while three nitrogen management options applied in sub-plots @ 150 kg N/ha were; N_1-1/2 at sowing + ½ at crown root initiation along with 20 kg N as starter dose given at time of field preparation; N_2-2/3 at sowing + 1/3 at crown root initiation and N_3-1/2 at sowing + ½ at crown root initiation. During *kharif* a uniform crop of rice was grown and during *rabi* wheat crop was raised as per treatment. The disposal of rice straw was made according to the treatment, while wheat straw was removed from the field owing to its greater demand for cattle. After harvesting of *kharif* rice grown under transplanted conditions, the wheat variety PBW 343 was sown on 4 December during 1999-2000 and 6 December during 2000-01.

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RESULTS AND DISCUSSION

Effect of tillage and rice residue management

Tillage and rice residue management practices marked significant variation on all the characters under study except soil pH and protein content (Table 1). The incorporation of rice residue into succeeding wheat crop with the help of either disc plough (T_3) or mould-board plough (T_2) was statistically similar. Similar observations were made by Bhadoria (1988) and Razzak *et al.* (1993). Either burning (T_7) or incorporation of rice residue by traditional tillage (T_4) or leaving the rice residue on soil surface using zero-till (T_5) or strip-till-ferti-seed drill (T_6) did not bring any significant differences in grain yield. Ediminster and Meelu (1989) also reported that crop yield remained at par in plots under minimum tillage when compared with conventional tillage. The lowest grain yield was registered from the residue removed traditionally tilled pot (T_1). The highest grain yield was recorded under incorporation of residue either by disc plough or mould-board plough is attributed to the production of significantly higher number of ears, grain growth duration and canopy temperature depression.

The incorporation of rice residue into wheat field by using either mould-board plough or disc plough proved best in production of significantly higher number of ear bearing shoots while, the removal or burning of residue in wheat field prepared by traditional tillage (T_1 and T_7) was poorer in generation of ear bearing shoots. Canopy temperature depression, which is a good indicator of the maintenance of favorable temperature and relative humidity in crop canopy, was found highest from the combine harvested plot sown by the operation of zero-till-ferti-seed drill, which was closely followed by strip-till-seed drill, mould-board plough and disc plough ploughed plots. The practice of crop residue management improves micro-climate that ultimately increases the grain yield. Amani *et al.* (1996) observed significant positive correlation between canopy temperature depression and grain yield.

Grain growth rate was highest under plot where crop was sown with the help of zero-till-seed drill, which was closely followed by strip-till-ferti-seed drill. Incorporation of residue either by disc plough or mould-board plough registered the lowest grain growth rate.

The available N status of respective plots analyzed after wheat harvest varied owing to tillage type and residue management, while the value for soil pH remained unchanged.

The retention or incorporation of crop residue, however showed a slight fall in soil pH values over residue burning, residue removal and initial value, but did not show statistical variations. It might be due to high buffering capacity of silty-clay soil which offered resistance against change in pH. Beri *et al.* (1992) also corroborated the results and concluded that residue management did not affect soil pH in a ten years experiment. Available N status of soil was remarkably increased and found highest in those plots where residue was retained on soil surface through conservation tillage or incorporation with the help of traditional method (T_4). The highest concentration of NPK in surface soil with a combination of no-tillage, crop residue retained and fertilizer nitrogen were also reported by Dalal, (1989). The trend was then followed by those plots which received deep incorporation of residue by mould-board and

Table 1. Effect of tillage/rice residue and nitrogen management on soil properties after crop harvest, nitrogen uptake and protein content of wheat (pooled data)

Treatments			Soil pH	Soil available N (kg/ha)	Nitrogen uptake (kg/ha)	Protein (%)	Protein yield (kg/ha)
Tilllage and residue management							
Mode of harvesting	Tillage implement						
(T_1) Hand	Harrow (6)		7.75	238.34	134.98	11.52	503
(T_2) Combine	MBP(1)+Harrow(4)		7.70	243.50	145.22	11.72	590
(T_3) Combine	DP(1)+Harrow(4)		7.65	246.28	148.29	11.71	593
(T_4) Combine	Harrow(6)		7.65	252.04	134.14	11.58	548
(T_5) Combine	Zero-till-drill		7.65	255.83	142.20	11.75	545
(T_6) Combine	Strip-till-drill		7.65	254.08	136.08	11.57	562
(T_7) Combine + burining	Harrow(6)		7.75	234.00	139.62	11.55	562
CD (P=0.05)			NS	7.68	4.07	NS	15
Nitrogen management (kg N/ha)							
Starter dose	Basal	CRI					
(N_1) 20	75	75	7.70	255.20	141.74	11.68	572
(N_2) -	100	50	7.70	254.33	141.08	11.61	566
(N_3) -	75	75	7.70	254.31	139.07	11.60	538
CD (P=0.05)			NS	NS	NS	NS	13

disc plough (T_2 and T_3). Burning and removal of residue led to the lowest accumulation of available N in surface soil. Beri *et al.* (1992) again were also of similar view.

Deep burying of rice residue with either disc plough (T_3) or mould board plough (T_2) brought significant results by providing the highest uptake of total N to crop mainly due to beneficial affect on physical and chemical property of soil that resulted in highest grain yield. It was followed by sowing of wheat crop in combine harvested plot using zero tillage (T_5) and residue burned traditionally tilled plot (T_7). The lowest uptake of N was recorded from the plot where rice residue was traditionally buried into soil with the help of harrowing only (T_4). So, the total nitrogen uptake seemed to be positively correlated with the grain yields produced under different tillage and residues management treatments. The results obtained are in close conformity with that of Nambiar and Abrol (1989).

A slight increase in protein content was observed under the deep incorporation of rice residue (T_2 & T_3) whereas, the lowest under residue removal. The protein yield obtained by multiplying the protein with grain yield was significantly higher under deep incorporation of residue, which was followed by zero-tillage and residue burned traditionally tilled plot (T_7). The non-significantly higher protein content and statistically higher grain yield produced under deep incorporation of rice residue might be the reason for higher protein yield. Residue removed traditionally tilled plot recorded the lowest protein yield. The protein yield seems to be increased in the same fashion as of nitrogen uptake and grain yield.

The higher wheat economics as evinced by net return obtained (Rs/ha) was under the deep incorporation of residue and was followed by residue retained zero-tilled sown crop. It might be attributed to the enhanced nutrient

Table 2. Canopy temperature depression (CTD), grain growth duration (GGD), grain growth rate (GGR), number of ear bearing shoots, grain yiled and economics of wheat as affected by tillage/rice residue and nitrogen managemnt (pooled data)

Treatments			CTD (°C)	GGD (days)	GGR (mg/day)	Number of ears/m^2	Grain yield (t/ha)	Net return (Rs/ha)
Tilllage and residue management								
Mode of harvesting	Tillage implement							
(T_1) Hand	Harrow (6)		6.10	35.7	1.19	342	4.49	27,201
(T_2) Combine	MBP(1)+Harrow(4)		6.55	30.3	1.11	421	5.05	32,705
(T_3) Combine	DP(1)+Harrow(4)		6.50	37.1	1.14	418	5.20	33,090
(T_4) Combine	Harrow(6)		5.95	37.2	1.18	388	4.80	29,380
(T_5) Combine	Zero-till-drill		6.90	33.3	1.30	394	4.96	32,622
(T_6) Combine	Strip-till-drill		6.80	35.2	1.25	378	4.81	31,230
(T_7) Combine + burining	Harrow(6)		5.95	35.3	1.19	357	4.96	31,437
CD (P=0.05)			0.40	2.26	0.06	20	0.16	
Nitrogen management (kg N/ha)								
Starter dose	Basal	CRI						
(N_1) 20	75	75	6.55	35.8	1.19	390	5.07	
(N_2) -	100	50	6.40	36.1	1.21	391	5.03	
(N_3) -	75	75	6.20	35.3	1.18	375	4.76	
CD (P=0.05)			NS	0.78	NS	8	0.10	

availability, good micro-climate and higher grain yield. The lowest net return was obtained in the residue removed traditionally tilled plot.

Effect of nitrogen management

Grain growth duration, grain growth rate, effective tillers, grain yield as well as protein yield were significantly affected due to schedule of nitrogen management. Application of 150 kg/ha in two equal halves along with 20 kg extra dose of N/ha (N_1) proved superior in production of the above traits of wheat crop. But it did not have any added statistical advantage over the yield registered by the application of 150 kg N/ha into splits of 2/3 as basal and remaining 1/3 at CRI (N_2). The plot enriched with 150 kg /ha applied in two equal splits (N_3) yielded lowest. Bali *et al.* (1986) reported that straw incorporation with starter dose of 20 kg N/ha gave higher grain yield in comparison to no-starter dose. The phenomenon of yield ranking is in line with the number of ears and grain growth duration. No influence of nitrogen management options was noticed on soil chemical properties, nitrogen uptake and protein content.

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COMBINING ABILITY IN TETTRAPLOID WHEAT FOR YIELD, YIELD ATTRIBUTING TRAITS, QUALITY AND RUST RESISTANCE

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Abstract

Combining ability for grain yield per plant and its components, quality traits and rust resistance was studied using five lines and seven testers and 35 crosses produced in LXT mating system in durum and emmer wheat. Analysis of variance for combining ability revealed that variance due to females, males and female x male was significant for all the traits studied. The general and specific combining ability variance ratio revealed the preponderance of non-additive gene action for all the traits. Significant gca effects for grain yield and its component traits was exhibited by the lines Vijay and DK-1001 and testers DWR-1006 and Raj-1555. Fourteen crosses recorded significant sea effects for grain yield and related traits.

Key words : *Triticum durum, Triticum dicoccum*, general combining ability, specific combining ability, non-additive gene effects.

Among the cultivated tetraploid wheat, durum wheat (*Triticum durum* Desf.) occupies 9 per cent of wheat area in India with approximately 2.7 million ha. and production is 2.5 million tones followed by emmer wheat with one percent area (Hanchinal, 2000). Durum wheat cultivation is common in central and peninsular India under rainfed condition/limited irrigation. Adaptation of these species to high temperature and moisture stress is mai8nly due o the presence of specific genes (Anderson, 1973). Durum wheat is known for its excellent qualities and various products are made and marketed as instant foods viz., *macaroni, sphaghatti, vermicelli, noodles*, instant *daila* and other ready-to-cook products. In Karnataka state, durum wheat is preferred for local preparations like *Upma* and *vermicelli.* Emmer wheat which can withstand high temperature is nutritionally superior as compared to commercially available bread and durum wheat with high protein and dietary fibre contents (Bhuvaneswari *et al.*, 1998). Information on genetic architecture of durum and emmer wheat is limited as compared to bread wheat. In the present investigation, LXT analysis (Kempthorne, 1957) was employed to study the magnitude of gene action controlling the inheritance of yield, related quantitative traits, quality parameters and disease resistance for the choice of parents and to adapt an efficient breeding programme.

Materials and Methods

Five line comprising of four durum wheat varieties NID-15, Bijaga Yellow, Vijay, MACS-2846 and one dicoccum wheat variety DDK-1001and six durum wheat varieties DWE-185, DWE-1006, MACS-1967, DWR-2006 and RAJ-1555 and one dicoccum variety NP-200 as testers were crossed in Line X Tester mating design during 2002-03 rabi season. 35 crosses produced and parents were evaluated in Randomized complete block design with two replications. In each replication, parents and F_1s were sown in a row of 2 meter length with the spacing of 23 cms between rows and 5 cms between plants. The data were recorded on five random plants for the characters viz., days to fifty per cent flowering, days to maturity, plant height (cm), peduncle length (cm), spike length (cm), number of spikes/m^2, number of tillers/plant, number of seeds/spike, total biomass/plant (g), thousand grain weight (g), grain yield/plant (g), harvest index, leaf rust reaction (per cent infection using cob's scale), protein content (Misra and Gupta, 1995) and semolina recovery (%). Combining ability analysis was performed as per Kempthorne (1957).

RESULTS AND METHODS

The analysis of variance indicated that variation among the parents and hybrids was significant for all the characters. The analysis of variance for combining ability (Table 1) revealed that the significant differences due to females, males and females x males for all the traits studies. Further the variance ration s2gca/s2sca suggested that additive genetic component is preponderant in the inheritance of all the characters except number of seeds/spike for which non-additive component was preponderant. The importance additive genetic variance for grain yield and other traits was also reported by Bebyakin and Korobiba (1990). Bebyakin and Starichkova (1991) and Kamat (1996).

The estimates of gca effects (Table 2) indicated that the lines Vijay and DDK-1001 and testers DWE-1006 and RAJ-1555 were the best general combiners for grain yield. The line Vijay also showed high gca effects for harvest index, number of seeds/spike, number of tillers/plant and height. Another line DDK-1001 showed significant gca effects in the desired direction for plant height, spike length, number spikes/m^2, number of tillers/plant, total biomass, thousand grain weight and leaf rust. The tester DWE-1006 exhibited significant gca effects for days to maturity, peduncle length, number of spikes/m^2, thousand grain weight, harvest index, leaf rust and protein content and another tester RAJ-1555 for plant height and leaf rust. For semolina recovery the line, NIDW-15 and testers NP-200, DWE-185 and MACS-3125 were found to be good general combinations. In general, there was a correspondence between gca effects and per se performance of the genotypes.

The 14 crosses which exhibited significant positive sca effects for grain yield were presented in Table 3. The cross NIDW-15 X DWR-1006 showed significant sca effects in respect of harvest index, semolina recovery, days to fifty per cent flowering, plant height and number of tillers/plant, for leaf rust, the cross combination NIDW-15 X RAJ-1555 regarded significant sca

Table 1. Analysis of variance for combining ability for fifteen quantitative traits in tetraploid wheat

Source	Days to 50% flowering	Days to maturity	Plant height	Peduncle length	Spike length	Spike /m^2	Tillers/ plant	Grains/ spike	Total biomass	1000-grain weight	Grain yeild /plant	Harvest index	Leaf rust	Protein content	Semolina recovery
Replication	3.23	40.1**	2.7	0.1	1.0*	25.6	0.3	2.8	0.9	6.9*	0.01	0.01	1.6	0.01	2.17
Females	34.6**	31.5**	268.7**	2.5**	7162.3**	12.3**	16.8**	80.2**	52**	10.7**	0.0103**	8.7**	17.3**	337.71**	
Males	94.85**	137.2**	33.45**	37.6**	3.3**	2090.0**	22.2**	137.2**	160**	34.7**	13.6**	0.0496**	22.7	9.2**	49.38**
Female X male	26.03**	30.6**	80.8**	10.7**	1.6**	3188.5**	9.8**	83.1**	82.5**	23**	11.9**	0.0293**	9.3**	1.2**	123.05**
Error	1.9	3	1.4	0.7	0.2	13.4	0.2	2.5	0.9	1.1	0.3	0.01	2.5	0.1	0.9
σ^2 gca/σ^2 sca	1.53	1.65	1.93	2.85	1.31	1.15	1.26	0.97	1.15	1.31	1.01	1.01	1.32	1.56	8.48

*Significant at 5%, **Significant at 1%

Table 2. General combining ability effects for fifteen quantitative traints in tetraploid wheat

Source	Days to 50% flowering	Days to maturity	Plant height	Peduncle length	Spike length	Spike /m²	Tillers/ plant	Grains/ spike	Total biomass	1000-grain weight	Grain yeild /plant	Harvest index	Leaf rust	Protein content	Semolina recovery	Overall GCA effects
Females																
NIDW-15	-1.37**	-1.36**	3.07**	0.98**	-0.22**	-1.50*	-0.07	-1.33**	-3.19**	-0.25	-1.36**	0.01**	0.05	1.78**	8.26**	A
B. Yellow	-0.80**	-1.57**	5.71**	3.47**	0.34**	22.93**	0.20*	0.31	3.38**	-1.50**	0.01	-0.04	1.17**	-0.72**	-0.96**	B
Vijay	0.20	0.29	-1.60**	0.17	-0.27**	-2207**	0.18*	1.60**	-0.76**	-1.81**	0.80**	0.03**	0.24	-1.11**	-0.66**	L
DDK-1001	2.63**	2.07**	-1.79**	-3.60**	0.55**	22.93**	1.15**	0.03	0.84**	2.99**	0.73**	0.00	-0.81**	-0.07	-4.76**	H
MACS-2846	-0.66**	0.57	-5.38**	-0.99**	-0.41**	-24.29**	-1.45**	-0.61*	-0.27	.57**	-0.18	-0.01**	-0.65*	0.13*	-1.91**	L
Males																
NP--200	5.09**	5.54**	6.76**	-0.27	1.00**	14.89**	2.73**	0.04	3.37**	1.41**	-1.51**	-0.09**	0.26	1.45**	3.03**	A
DWR-185	-4.01**	-4.44**	2.56**	0.29	-0.40**	19.76**	0.85**	-3.26**	-4.59**	0.33	0.16	0.07**	-2.07**	-0.38**	1.70**	A
DWR-1006	0.49	-2.34**	6.46**	2.74**	-0.05	9.49**	-1.72**	-1.56**	-3.94**	0.53	0.83**	0.09**	-1.18**	0.98**	0.30	H
MACS-3125	-3.41**	-3.84**	-7.54**	-3.13**	-0.65**	-8.91**	-0.59**	5.04**	-0.65**	-2.01**	-0.27**	0.01	-0.57*	-0.23**	1.06**	L
MACS-1967	-0.21	2.66**	0.95**	1.20**	0.49**	-10.21**	0.41**	4.24**	6.82**	2.76**	0.31*	-0.09**	-0.05	-0.92**	-0.77**	A
DWR-2006	0.39	0.36	-2.78**	0.89**	-0.40**	-17.71**	-0.90**	0.54	-1.05**	-2.53**	-1.32**	-0.01**	2.53**	0.23**	-3.58**	L
RAJ-1555	1.66**	2.06**	-6.42**	-1.69**	0.02	-7.31**	-0.79**	-5.04**	0.04	0.49*	1.80**	0.04**	1.08**	-1.14**	-1.71**	L
SE for lines	0.28	0.36	0.24	0.17	0.08	0.75	0.09	0.33	0.20	0.22	0.12	0.00	0.33	0.06	0.20	
SE for testers	0.34	0.44	0.29	0.21	0.10	0.92	0.10	0.40	0.24	0.27	0.15	0.00	0.40	0.07	0.24	

*Significant at 5%, **Significant at 1%

A- Average H- High L-Low

Table 3. Specific combining ability effects for specific crosses in tetraplod wheat

Source	Days to 50% flowering	Days to maturity	Plant height	Peduncle length	Spike length	Spike /m²	Tillers/ plant	Grains/ spike	Total biomass	1000-grain weight	Grain yeild /plant	Harvest index	Leaf rust	Protein content	Semolina recovery
NIDW-15 x DWR-1006	-1.63*	1.06	-7.65**	-2.42**	-0.11	0.80	0.97**	-4.37**	-3.28**	-0.73	2.81**	0.18**	3.22**	-1.24**	6.38**
NIDW-15 x RAJ-1555	2.67**	3.16**	5.48**	2.46**	-0.08	-26.40**	-1.21**	-7.37**	2.94**	-1.86**	1.83**	0.00	-1.89*	1.52**	-16.71**
B. Yellow x DWR-185	1.80**	1.37	0.81	1.94**	0.78**	50.07**	-0.27	-3.81**	5.40**	2.87**	1.61**	-0.05**	-1.16	-0.79**	-8.07
B. Yellow x DWR-2006	-1.10	0.57	-0.75**	-0.81*	0.03	-16.93**	-0.72**	5.89**	12.74**	-1.27**	1.69**	0.25**	0.94	0.11	-1.39**
Vijay x DWR-185	-1.70**	-2.49**	4.32**	2.59**	-0.06	47.07**	0.20	7.40**	0.24**	-0.22	1.22**	0.04**	0.42	-0.81**	8.03**
Vijay x DWR-1006	-0.20	-1.59**	-1.28**	-1.66**	0.24	-23.63**	1.42**	1.20	-1.61**	-0.87	1.35**	0.07**	-0.04	1.15**	-10.77**
DDR-1001 x DWR-1006	0.37	-3.37**	2.21**	1.54**	0.02	-27.63*	-0.55**	1.27	1.59**	-3.62**	1.62**	0.01	-0.77	0.26*	0.28
DDK-1001 x MACS-3125	0.77	-0.87	-8.29**	-3.19**	0.12	6.77**	2.72**	-3.33**	-3.20**	1.77**	0.10**	-1.03	0.02	3.12**	
DDK-1001 x DWR-2006	4.47**	-2.57**	4.25**	0.19	-1.13**	23.07**	-3.57**	-13.33**	-6.80**	3.14**	1.32**	0.13**	0.22	0.15	-14.19**
DDK-1001 x RAJ-1555	-4.33**	-2.77**	-2.11**	0.47	1.15**	55.67**	-0.13	4.27**	4.86**	0.35	2.64**	-0.01	3.82**	-0.92**	8.04**
MACS-2846 x NP-200	-1.44**	-2.77**	7.70**	1.66**	-0.32	5.19**	-3.14**	0.81	1.34**	-1.33**	3.22**	0.07**	0.98	-0.63**	-2.80**
MACS-2846 x DWR-185	1.16	-0.27	-3.80**	-3.30**	0.53**	13.79**	4.18**	-7.39**	1.55**	-0.65	2.30**	0.04**	0.66	0.08	-0.62
MACS-2846 x MACS-3125	0.06	0.63	-7.10**	-2.33**	-0.77**	-16.01**	-1.38**	3.81**	-7.89**	-4.83**	0.53*	0.16**	0.61	0.74**	-4.83**
MACS-2846 x MACS-1967	3.86	7.13**	7.01**	2.74**	1.74**	60.79**	-0.83**	0.61	3.84**	-4.63**	3.65**	0.04**	4.34**	0.07	-3.65**
SE (Sg)	0.69	0.88	0.59	0.41	0.20	1.85	0.21	0.80	0.48	0.53	0.29	0.01	0.81	0.15	0.49

*Significant at 5%, **Significant at 1%

effects in the desired direction in addition in addition to protein content, total biomass and peduncle length. The crosses BIJAGA YELLOOW X DWR -185, DDK-1001 X MACS-3125 and DDK-1001 X DWR-2006 exhibited significant positive sca effects for thousand grain weight. For number of spikes/m^2 and number of tillers/plant the crosses DDK-1001 X MACS-3125 and MACS-2846 X DWR-185 showed significant positive sca effects. Significant negative sca effects for days to maturity exhibited by the crosses VIJAY X DWR-185, VIJAY X DWR-1006, DDK-1001 X DWR-1006, DDK-1001 X DWR-2006, DDK-1001 X RAJ-1555 and MACS-2846 X NP-200 indicating the earliness.

The cross DDK-1001 X DWR-1006 with significant sca effects for grain yield involved both the parents with high gca effects indicating predominance of additive genetic variation and hence progeny selection in the segregating generations will be more effective for further genetic improvement. The remaining crosses with significant sca effects for grain yield involved the parents with low x low, low x average and high x low gca effects revealing the presence of non-allelic interactions. Therefore, recurrent selection programmes could be followed for substantial genetic improvement.

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GROWTH AND YIELD OF *RABI* GROUNDNUT (*ARACHIS HYPOGAEA* L.) AS INFLUENCED BY MOISTURE REGIMES, POLYTHENE MULCH AND PLANT DENSITIES

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ABSTRACT

A field trail to study the effect of growth wise irrigation regimes, mulching and plant densities on growth and yield attributing characters and yield of *rabi* groundnut was conducted at College of Agriculture Farm, Depoli, Distt. Ratnagiri. (M.S.) during *rabi* season of 2001-02 and 2002-03. Results based on pooled data indicated that growth wise irrigation scheduling at 0.6:1.0:0.8 IW/CPE ratios recorded significantly higher per plant growth in terms of height, number of leaves, branches and dry matter accumulation, from 60 days after sowing (DAS) to harvest (120 DAS) and subsequently the per plant yield parameters such as number and weight of mature pods, kernels and 100 kernel weight, shelling percentage ; which resulted into significantly higher dry pod and haulm yield over all other irrigation treatments. Similarly, polythene mulch recorded significantly higher growth, attributing characters from 30 DAS upto harvest and subsequently the yield attributing characters and yield, as compared to no mulch treatment. Further, the lower plant density (4,44,444 plant ha^{-1}) produced significantly higher growth, yield attributing characters refered above and yield of groundnut, over higher plant density (5,55,555 plant ha^{-1}) except in case of height that was significantly higher under the higher plant density than the lower plant density.

Key words : Irrigation regimes, polythene mulch, planting density, growth and yield.

India holds premier position in the global oil seeds scenario accounting for 19 per cent of the total area and 9 per cent of the total oil seed production. However, the productivity per unit area is only 935 kg/ha (1998-99) as compared to world level of 1632 kg/ha. Average productivity of groundnut is relatively low as it is mostly growth rainfed during the *kharif* season. Productivity of the irrigated summer crop is 2 to 3 times higher than the rainfed crop crop. In Konkan region, under lateritic soil conditions, groundnut crop is irrigated at 0.8 IW/CPE ratio from sowing upto maturity. However, at early vegetative stage because of small growth and at maturity stage because of senescence, the water requirement of groundnut crop is less as compared to flowering, pegging and pod formation stages which are most sensitive to irrigation. Taking into consideration the differential water requirement of the crop at various growth stages it was necessary to quantify the stage wise optimum requirement of irrigation water for better growth and higher yield of *rabi* groundnut. Secondly, the polythene mulch has a positive effect in developing the congenial condition in terms of soil moisture and temperature that enhance the moisture extraction, nutrient uptake simultaneously growth and ultimately the yield of groundnut. Therefore, to assess the extent of positive effect of polythene mulch over control, three treatments were incorporated in the study. The medium duration bunch varieties required comparatively less area than the late spreading types. Therefore, there is scope to increase the plant density either by changing the row spacing or by increasing number of plants in a row. Therefore, the present investigation was undertaken to study the effect of irrigation regimes, polythene mulch and plant densities on growth and yield of *rabi* groundnut under lateritic soil conditions of Konkan region in Maharashtra.

MATERIALS AND METHODS

A field experiment was conducted at the College of Agriculture Farm, Dapoli, Distt.

Ratnagiri (M.S.) during *rabi* season of 2001-02 and 2002-03. The soil of experimental plot was lateritic, clay loam with acidic in reaction (pH 6.35), the water table was below 5 metre. Field capacity and permanent wilting point were 28.0 and 16.4 per cent, respectively. The soil was medium in available nitrogen (197.32 kg ha^{-1}), low in available phosphorus (18.91 kg ha^{-1}) and fairly high in available K_2O (295.0 kg ha^{-1}). In all five irrigation schedules viz., 0.8:0.8:0.8 IW/CPE ratios (I_1), 0.6:0.8:0.8 IW/CPE ratios (I_2), 0.6:0.8:1.0 IW/CPE ratios (I_3), 0.6:1.0:0.8 IW/CPE ratios (I_4) and 0.6:0.8:0.6 IW/CPE ratios (I_5) were included under the main plots, two mulching treatments i.e., polythene mulch (P_1) and no mulch (P_0) were taken under sub-plot and two plant densities i.e., 4,44, 444 plants ha^{-1} (D_1) and 5,55,5555 plants ha^{-1} (D_2) were included under sub-sub plot. The trial was laid out in split plot design with three replications. The gross and net plot sizes were 4.5 x 3.5 m^2 and 4.2 x 3.3 m^2, respectively. The crop was sown on 9 and 12, December during 2001 and 2002, respectively. FYM @ 10 t ha^{-1} was thoroughly mixed with soil at the time of land preparation. Broad bed furrow having width of 90 cm at bottom, 60 cm at top with 10 cm height were prepared. All the treatments received uniform basal dose of 50 kg N, 100 kg P_2O_5, 50 kg K_2O and 300 kg gypsum ha^{-1}. Irrigation were applied at different IW/CPE ratios of 0.6, 0.8 and 1.0 as per the treatment schedule. In all 8, 8, 8, 9, and 7 irrigations were given to I_1,I_2,I_3,I_4 and I_5 treatments, respectively including two common irrigations given to all treatments, at the time of sowing and emergence. Polythene mulch of 7 micron having holes of 5 cm diameter at 15x10 cm^2 (D_1) and 10x10 cm^2 spacing (D_2) was spread on broad bed furrow (BBF) just before sowing. Sowing on BBF was done by dibbling two seeds per hill as per the spacings. Observations on growth parameters (Table 1) were recorded at 30 days interval. Similarly, the observation on yield attributes and yield (Table 2) were recorded after harvesting. Common plant protection measures for controlling insect, pest and weeds were undertaken as and when necessary during the life period of the crop.

RESULTS AND DISCUSSION

Effect of irrigation

Data presented in Table 1 revealed that the scheduling of irrigation @ 0.6:1.0:0.8 IW/CPE ratios (I_4) i.e., upto 40 DAS (upto flowering initiation) : 40 to 80 DAS (flowering to early pod formation) : 80 DAS to maturity (pod formation to maturity) recorded significantly higher plant growth in terms of height, number of leaves, number of branches, dry matter accumulation, from 60 DAS to maturity and yield parameters such as number of mature pods and kernels and their weight per plant, 100 kernel weight, shelling percentage and subsequently dry pod and haulm yield over all other irrigation treatments. Irrigation scheduling @ 0.6:0.8:0.6 I/W/CPE ratios recorded significantly the lowest growth and yield attributing parameters and yield, than all the other irrigation treatments. This has indicated that the initial stress upto 40 DAS (upto flowering initiation) @ 0.6 IW/CPE ratio has beneficial effect in terms of better root growth and sychronous early flowering. Further, flowering, pegging and pod formation stages are most sensitive to moisture stress and during these stages, crop obtained sufficient moisture @ 1.0 IW/CPE ratio and hence it has produced higher growth and yield while in other irrigation levels the crop was irrigated at 0.6 or 0.8 IW/CPE ratios during the above referred critical stages and hence these treatments experienced greater stress than the above referred treatment (I_4) and therefore, recorded significantly less growth and yield in the pooled data. These results are in conformation with those reported by Shinde and Pawar (1984).

Effect of polythene mulch

As regards the mulching, polythene mulch produced significantly higher values of the growth attributing characters such as height, number of leaves, branches and dry matter accumulation per plant from 30 DAS to maturity ; yield attributing characters such as number and weight of mature pods and kernels per plant, 100 kernel weight, shelling percentage and dry pod and haulm yield ha^{-1} than no mulch in the pooled data. The increase in dry pod yield due to polythene mulch was to the tune of 46.54

Table 1. Growth attributing characters of groundnut as influenced by different treatments during 30, 60, 90 DAS and at harvest (Pooled data, 2001-02, 2002-03)

Treatments	Plant height (cm)				No. of Leaves/plant				No. of Branches/plant				Dy matter/plant (g)			
Irrigation (IW/CPE ratio) I II III	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
I_1 0.8:0.8:0.8	2.16	8.05	16.48	16.89	18.60	37.90	45.49	39.20	4.77	5.79	5.48	5.48	0.82	4.87	16.87	23.42
I_2 0.6:0.8:0.8	2.11	7.80	16.38	16.60	18.50	38.40	45.09	38.50	4.69	5.76	4.88	4.91	0.81	4.06	16.37	23.25
I_3 0.6:0.8:0.1	2.11	7.65	16.45	16.65	18.60	38.00	45.05	38.00	4.68	5.75	4.89	4.90	0.81	4.10	17.00	23.35
I_4 0.6:0.1:0.8	2.11	8.50	18.05	18.60	18.50	40.21	47.60	45.70	4.69	6.33	6.58	6.39	0.81	5.99	20.58	26.68
I_5 0.6:0.8:0.6	2.11	7.80	16.48	16.50	18.00	38.10	45.05	34.90	4.69	5.75	4.89	4.85	0.81	4.06	16.54	20.80
SE±	0.80	0.14	0.35	0.41	0.20	0.36	0.15	0.44	0.03	0.02	0.30	0.30	0.02	0.30	0.35	0.50
CD at 5% level	NS	0.42	1.05	1.23	NS	1.06	0.45	1.35	NS	0.06	0.90	0.90	NS	0.90	1.05	1.50
Mulch																
P0 No mulch	2.00	7.45	15.45	15.60	16.65	33.70	38.70	36.10	4.37	5.10	4.95	4.47	0.71	3.70	15.43	21.15
P1 Polythene mulch	2.24	9.10	18.21	18.72	20.15	43.00	48.00	42.70	5.05	6.85	5.71	6.13	0.90	5.60	19.70	25.50
SE±	0.05	0.30	0.40	0.30	0.11	0.40	0.05	0.64	0.20	0.30	0.23	0.35	0.70	0.31	0.80	0.30
CD at 5% level	0.15	0.90	1.20	0.90	0.33	1.20	0.15	1.90	0.60	0.90	0.70	0.05	NS	0.90	2.40	0.90
Plant density (Plant ha^{-1})																
D1 4, 44, 444	2.05	7.55	16.31	16.40	19.45	39.60	45.59	42.70	4.84	6.29	5.64	5.72	0.85	5.21	18.60	24.50
D2 5, 55, 555	2.18	8.20	17.35	17.50	17.20	37.00	39.89	36.00	4.60	5.43	5.22	4.88	0.79	4.20	16.40	22.20
SE±	0.05	0.20	0.20	0.30	0.78	0.40	0.05	1.10	0.20	0.28	0.14	0.28	0.03	0.30	0.70	0.60
CD at 5% level	NS	0.60	0.60	0.90	NS	1.20	0.15	3.30	NS	0.80	0.40	0.80	NS	0.90	2.10	1.80

I : upto 40 DAS　　II : 40 to 80 DAS　　III : 80 DAS to maturity

Table 2. Yield attributes and yield of groundnut as influenced by different treatments (pooled data, 2001-02 and 2002-03)

Treatments	No. of matured pod/plant	Weight of matured pods/plant (g)	No. of Kernels/plant (g)	Weight of Kernels/plant (g)	100 Kernel weight (g)	Shelling percentage	Dry pod yield (q/ha)	Haulm yield (q/ha.)
I_1 0.8:0.8:0.8	15.20	13.16	30.60	10.22	43.00	71.65	40.60	40.20
I_2 0.6:0.8:0.8	14.30	12.46	30.10	9.95	42.77	71.50	39.90	39.34
I_3 0.6:0.8:0.1	14.20	12.30	30.60	9.91	42.71	71.25	39.60	40.05
I_4 0.6:0.1:0.8	17.21	16.10	43.50	11.30	43.30	73.80	43.80	44.36
I_5 0.6:0.8:0.6	11.00	9.38	21.00	7.20	40.60	62.40	29.40	28.11
SE±	0.08	0.36	0.20	0.11	0.40	0.23	0.40	0.36
CD at 5% level	0.21	1.08	0.60	0.33	1.20	0.67	1.20	1.09
Mulch								
P0 No mulch	14.53	10.19	26.00	7.74	40.80	69.19	28.66	30.25
P1 Polythene mulch	16.32	15.16	35.60	11.62	44.00	71.48	48.70	45.10
SE±	0.03	0.31	0.40	0.40	0.30	0.21	0.37	0.40
CD at 5% level	0.08	0.93	1.20	1.20	0.90	0.63	1.04	1.20
Plant density (Plant ha^{-1})								
D1 4, 44, 444	16.30	14.75	37.60	11.13	43.50	71.17	40.11	39.94
D2 5, 55, 555	12.00	10.60	29.00	8.21	41.40	69.49	37.26	35.36
SE±	0.07	0.36	0.90	0.40	0.13	0.21	0.49	0.50
CD at 5% level	NS	1.08	NS	1.20	0.37	0.60	1.40	1.50

I : upto 40 DAS II : 40 to 80 DAS III : 80 DAS to maturity per cent than no mulch treatment. It might be due to the beneficial effect of polythene mulch in terms of higher soil temperature and water which might have resulted into better root growth, microbial activities, nutrient availability and hence better growth and yield performance of groundnut crop under polythene mulch than no mulch. Similar findings were reported by Hu, *et al.* (1995).

Effect of plant density

Plant population of 4, 44, 444 plant ha^{-1} (D_1) recorded significantly higher plant growth in terms of number of leaves, branches and dry matter accumulation per plant from 60 DAS to maturity than higher plant population of 5,55,555 (D_2) plants ha^{-1} in the pooled data. However, the plant height was significantly higher under the higher plant population than the lower plant population due to completion for sunlight under the higher plant density. This significant performance of groundnut plant under lower plant density further resulted into significantly higher number and weight of mature pods and kernels per plant and subsequently higher dry pod and haulm yield under the lower plant density (D_1) than under the higher density (D_2) in the pooled data. It was the effect of less interplant competition among the lower plant density. Due to the intense interplant competition among the high density crop for the various resources, the yield reduced significantly than the lower plant density. Similar results were also obtained by Deshmukh and Bhoi (1999).

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EXTRACTANTS AND CRITICAL LIMITS OF AVAILABLE SOIL SULPHUR FOR MUSTARD (*BRASSICA CAMPESTRIS* VAR. TORIA)

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ABSTRACT

Pot experiments were conducted for two years using four levels of sulphur (0, 10, 20 and 30 mg S kg^{-1} soil) in twenty five soils representing five major soil orders (Entisols, Inceptisols, Alfisols, Mollisols and Vertisols) of India to assess the suitability of fourteen extractants for establishing critical limit of available soil sulphur for mustard (Brassica campestris var. Toria). The soils were extracted with 0.15% $CaCl_2.2H_20$, 500 mg P L^{-1} $Ca(H_2PO_4)_2$, Wolf, Mehlich-2, Mehlich-3, Mehlich-3 + charcoal, modified calcium chloride (0.15% $CaCl_2.2H_2O$ + 0.5M CH_3COONH_4 + 0.5M CH_3COOH), 0.25M KCl at 40°C, 0.25M KCl at 50°C, 0.25M KCl at 50°C + charcoal, 0.25M KCl at 60°C, 0.25M KCl at 60°C + charcoal, 500 mg P L^{-1} KH_2PO_4 and 0.125M KCl + 0. 075%$CaCl_2.2H_2O$ at 50°C extractants. The soil sulphur content extracted by using 500 mg P L^{-1} KH_2PO_4, 500 mg P L^{-1} $Ca(H_2PO_4)_2$. H_2O, and 0.25M KCl at 60°C + charcoal did not correlation significantly with any or most of the biological indices of mustard, which indicated that these extractants are not suitable for predicting soil sulphur availability to mustard. On the basis of the magnitude of correlation coefficients with biological indices of mustard, 0.25M KCl at 40°C was found to be most suitable extractant followed by multinutrient extractant Mehlich-3 + charcoal and 0.25M KCl at 50°C + charcoal than other extractants studied with critical limits of 6.9, 8.2 and 13.5 mg S kg-1 soil, respectively. The critical concentration of sulphur in 60 days old mustard plants tissue was found to be 0.51% on dry weight basis.

Key words : Mustard, sulphur, soils, extraction, correlation coefficient, critical limit, tissue sulphur content, multinutrient extractants.

Critical limits of available soil sulphur for mustard in Indian soils have been established by using various extractants and methods of estimation. Different critical values of available sulphur in a particular soil for mustard are reported for different extractants (Murthy, 2004). Moreover, these limits varied with the soil as well as the extractants used within the same soil (Bloem *et al.*, 2002), making the soil testing for available sulphur as a diagnostic tool of limited utility. It emphasized the need for the standardization and development of an universally acceptable extractants of available sulphur using soils of widely ranging characteristics so that inconsistency in critical limit of available sulphur for mustard crop may be removed. Therefore, the present work was under taken in order to evaluate the suitability of selected commonly used, multinutrient, 0.25M KCl-heat treatment (Blair *et al.*, 1991), modified 0.25M KCl-heat treatment and some new extractants to select the most promising extractants to predict the availability of soil sulphur to mustard grown on soils of widely varying physico-chemical properties.

MATERIALS AND METHODS

Bulk surface soils samples (0-15 cm) varying widely in physico-chemical properties and 0.15% $CaCl_2.2H_2O$ (Williams and Steinbergs, 1959) extractable sulphur content were collected from twenty five selected sites representing Entisols, Inceptisols, Mollisols, Alfisols and Vertisols soil orders. The percentage of sand, silt and clay in initial soil samples were varied from 6 to 80, 6 to 46 and 5 to 56, respectively. The pH (1:2.5, soil : water) of soils varied from 5.6 to 8.0, electrical conductivity from 0.07 to 0.82 dSm^{-1}, organic carbon from 1.9 to 12.2 g kg^{-1}, CEC from 5.60 to

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33.60 cmol (p+) kg^{-1} $CaCO_3$ from 0.05 to 3.95% and free iron oxide 0.1 to 0.6%.

Pot experiments were conducted for two consecutive years during *rabi* season. Eight kilograms of air dry processed soils were taken in polythene lined ten kg capacity earthen pots. Four levels of sulphur *viz.* control (no sulphur), 10, 20, and 30 mg S kg^{-1} soil were applied as ammonium sulphate. A uniform dose of 60 mg kg^{-1} of nitrogen through urea was applied in two equal splits. P_2O_5 and K_2O were applied through KH_2PO_4 and KCl @ 30 and 25 mg kg^{-1}, respectively. Amount of N and K_2O added through ammonium sulphate and KH_2PO_4 were taken into account. Five mustard (var. Pusa Agrani) seeds were sown and three mustard plants were retained for the study in both the years. The experiment was laid in C.R.D. with three replications. Plants were harvested 60 days after sowing. The dry matter yield was recorded after attaining the constant weight by drying in oven at 65 ± 2° C. One gram of ground dried plant material was digested in di-acid mixture and volume was quantitatively made up to 100 ml with distilled water. Sulphur

Table 1. Chemical composition of extractants and average soil sulphur content (mg/kg) extracted by various methods

Extractants	Chemical composition of extractants	Soil : solution ratio	Shaking time (minutes)	Range (mg S kg^{-1})	Mean (mg S kg^{-1})	References
$CaCl_2$	0.15% $CaCl_2.2H_2O$	1:5	30	1.3-166.4	12.7	Williams and Steinberg (1959)
$Ca(H_2PO_4)_2$	500 mg P L^{-1} $Ca H_2PO_4)_2.H_2O$	1:5	60	1.2-555.9	60.3	Fox *et al.* (1964)
Wolf	1.0 M CH_3COONa + 25 ml L^{-1} CH_3COOH + 0.18 g L^{-1} DTPA	1:5	30	1.5-359.7	28.3	Wolf (1982)
Mehlich-2	0.2 N CH_3COOH + 0.02 N NH_4Cl + 0.015 N NH_4F + 0.012N HCl	1:10	05	3.5-345.8	24.5	Mehlich (1978)
Mehlich-3	0.2 N CH_3COOH + 0.25 N NH_4NO_3 + 0.15N NH_4F + 0.013 N HNO_3 + 0.001M EDTA	1:10	05	1.5-252.1	56.1	Mehlich (1984)
Mehlich-3 + Charcoal	—do— + 0.5 g Charcoal	1:10	05	2.2-219.6	29.5	Modified from Mehlich (1984)
Modified $CaCl_2$	0.15% $CaCl_2.2H_2O$ + 0.5 M CH_3COONH_4 + 0.5 M CH_3COOH	1:5	30	1.1-492.5	29.3	New extractant
KCl at 40°C for 3hr	0.25 M KCl	1:6.7	180	4.0-173.1	19.7	Blair *et al.* (1991)
KCl at 50°C for 3hr	0.25 M KCl	1:5	180	1.3-150.6	17.1	Modified from Blair *et al.* (1991)
KCl at 50°C for 3hr + charcoal	0.25 M KCl + 0.5 g Charcoal	1:5	180	1.2-143.5	14.6	Modified from Blair *et al.* (1991)
KCl at 60°C for 3hr	0.25 M KCl	1:5	180	1.7-201.6	24.1	Modified from Blair *et al.* (1991)
KCl at 60°C for 3hr + charcoal	0.25 M KCl + 0.5 g Charcoal	1:5	180	1.2-196.0	21.3	Modified from Blair *et al.* (1991)
KH_2PO_4	500 mg P L^{-1} KH_2PO_4	1:5	60	3.3-81.0	23.4	Ensminger (1954)
KCl + $CaCl_2$ at 50°C for 3 hr	0.125 M KCl + 0.075% $CaCl_2.2H_2O$	1:5	180	2.5-238.3	21.9	New extractant

content of plant sample was determined by turbidimetric method.

Soil samples collected before sowing of mustard were extracted with fourteen extractants/methods including multi-nutrient and new extractants (Table 1) and analysed by turbidimetric method of Chesnin and Yien (1950). Some soils when extracted with Mehlich-3 and 0.25 M KCl-heat treated over 50°C resulted in coloured extracts and hence extraction was also carried out with the addition of 0.5 g sulphur free activated charcoal (Lee *et al.*, 1981). The simple correlation coefficients between the amounts of sulphur extracted by different extractants and biological indices of mustard plant were worked out to find out the suitability of various extracts studied (Table 2). For establishing the critical limits with respect to sufficiency of sulphur in soil both graphical and statistical methods of Cate and Nelson (1965 and 1971) were used.

Results and Discussion

Suitability of the extractants

The average content of sulphur extracted by various extractants from the soils varied widely and were found to be in the following decreasing order 500 mg P L^{-1} $Ca(H_2PO_4)_2$ > Mehlich-3 > Mehlich-3 + charcoal > modified 0.15% $CaCl_2$ > Wolf > Mehlich-2 > 0.25 M KCl at 60°C > 500 mg P L^{-1} KH_2PO_4 > 0.125 M KCl + 0.075% $CaCl_2$ > 0.25 M KCl at 60°C + charcoal > 0.25 M KCl at 40°C > 0.25 M KCl at 50°C > 0.25 M KCl at 50°C + charcoal > 0.15% $CaCl_2$ (Table 1). The difference in the level of sulphur extracted by Mehlich-3 with and without charcoal was ascribed to the removal of colour and colloidal organic matter interference on addition of charcoal (Lee *et al.*, 1981). These variations in

Table 2. Critical limit of available soil sulphur and correlation coefficients (r) between chemical extraction methods and biological indices of mustard

Extractants	Critical limit of available soil sulphur (mg S kg^{-1})	Correlation co-efficient (r)					
		Per cent relative dry matter yield	Per cent relative tissue sulphur content	Per cent relative sulphur uptake	Dry matter yield in control pots	Plant sulphur content of control pots	Sulphur uptake from control pots
0.15% $CaCl_2.2H_2O$	4.5	0.351	0.408*	0.517**	0.461*	0.360	0.548**
500 mg P L^{-1} Ca $(H_2PO_4)_2.H_2O$	10.5	0.394	0.379	0.508**	0.352	0.363	0.507**
Wolf	6.6	0.321	0.428*	0.532**	0.370	0.390	0.534**
Mehlich-2	8.8	0.362	0.407*	0.521**	0.463*	0.363	0.553**
Mehlich-3	23.3	0.206	0.477*	0.501*	0.399*	0.402*	0.518**
Mehlich -3 + charcoal	8.2	0.248	0.483*	0.556**	0.443*	0.442*	0.549**
Modified 0.15% $CaCl_2.2H_2O$	10.2	0.360	0.401*	0.515**	0.444*	0.353	0.537**
0.25*M* KCl 3hr 40°C	6.9	0.405*	0.454*	0.569**	0.517**	0.400*	0.594**
0.25*M* KCl 3hr 50°C	16.8	0.382	0.444*	0.556**	0.509**	0.368	0.583**
0.25*M* KCl 3hr 50°C + charcoal	13.5	0.372	0.438*	0.551**	0.500*	0.384	0.578**
0.25*M* KCl 3hr 60°C	15.4	0.372	0.397*	0.504*	0.487*	0.333	0.525**
0.25*M* KCl 3hr 60°C +charcoal	11.0	0.368	0.387	0.496*	0.487*	0.323	0.518**
500 mg P L^{-1} KH_2PO_4	18.5	0.233	0.151	0.246	0.022	0.192	0.232
0.125*M* KCl + 0.075% $CaCl_2 2H_2O$ 3hr 50°C	19.5	0.377	0.404*	0.519**	0.458*	0.361	0.546**

**and* significant at 0.01 and 0.05 probability levels, respectively.

extractable soil sulphur content by various extractants were due to differences in their nature and strength for extraction of soil sulphur from various soil sulphur pools (Athokpam *et al.*, 2004).

The sulphur content extracted by all the extractants used showed positive correlation with biological indices of mustard with varying magnitude of correlation coefficients (Table 2). All the extractants gave non-significant positive correlation with per cent relative yield except by 0.25M KCl 3hr 40°C (0.405*). Similarly, most of the extractants studied correlated non-significantly with per cent tissue sulphur content of mustard except Mehlich-3 (402*), Mehlich-3 + charcoal (0.442*) and 0.25 M KCl at 40°C (0.400*). All the evaluated extractants/methods were significantly correlated with sulphur uptake and relative sulphur uptake except with 500 mg P L^{-1} KH_2PO_4 (0.204).

The soil sulphur content extracted by using 500 mg P L^{-1} KH_2PO_4, 500 mg P L^{-1} $Ca(H_2PO_4)_2.H_2O$, Wolf and 0.25 M KCl at 60°C + charcoal gave non significant correlation with most of the plant parameters of mustard, which indicated that these extractants were not suitable for predicting soil sulphur availability to mustard (Table 2). Similarly, 0.15% $CaCl_2$, Mehlich-2, modified 0.15% $CaCl_2$, 0.25 M KCl at 50°C, 0.25 M KCl at 50°C + charcoal, 0.25 M KCl at 60°C and 0.125 M KCl + 0.075% $CaCl_2$ did not show significant correlation with per cent relative dry matter yield and plant sulphur content of control plots, which indicated the limitation of these extractants for predicting availability of soil sulphur to mustard. Matula (1999) has also found unsatisfactory sulphur bioavailability correlation with 0.15% $CaCl_2$ and Mehlich-2 extractants for mustard in the soils of Czech Republic. Only 0.25M KCl 3hr 40°C gave significant correlation with all of the biological indices of mustard out of the fourteen extractants studied. As most of the soils (80%) gave light to dark pink colour with Mehlich-3, so it cannot be recommended soil sulphur extractant without the use of charcoal. It revealed that 0.25M KCl 3hr 40°C was most suitable soil extractant for predicting soil S availability to mustard followed by multinutrient extractant Mehlich-3 + charcoal and 0.25 M KCl at 50°C + charcoal (Table 2). Suitability of 0.25M KCl 3hr 40°C and 0.25 M KCl at 50°C + charcoal has been reported by Pandey and Girish (2007) for maize. However, 0.25M KCl 3hr 40°C gave higher magnitude of correlation coefficient than most widely used 0.15% $CaCl_2$ extractant probably because of its ability to extract both sulphate and considerable amount of the HI-reducible labile organic sulphur fraction (Blair *et al.* 1991). Chinoim *et al.* (1997) also reported that the 0.25M KCl 3hr 40°C performed well for radish, corn and ryegrass as compared to mono-calcium phosphate on both the granite and basalt derived soils. Pandey and Girish (2006) reported that Mehlich-3 + charcoal could be a useful index for predicting the S requirement for cowpea in the similar soils.

Critical limits of available soil sulphur for mustard by various extractants

The critical limits of available soil sulphur by various extractants for mustard have been reported in Table 2. On the basis of the magnitude of correlation coefficient with plant parameters 0.25M KCl 3hr 40°C was found to be most suitable extractant for mustard followed by Mehlich-3 + charcoal and 0.25M KCl 3hr 50°C + charcoal than other extractants studied. The critical limit of available soil sulphur obtained with 0.25 M KCl at 40°C extractant (6.9 mg S kg^{-1} soil) in the present study corresponded well with the result of Blair *et al.* (1994) for pasture soils (6.5 mg S kg^{-1} soil), which is due to removal of soil sulphur by this extractant from pools similar to those reached by the crops (Chinoim *et al.*, 1997).

Critical limit of sulphur in mustard plant tissue

By graphical method of Cate and Nelson (1965) the critical concentration of sulphur in 60 days old mustard plant tissue was found to be 0.51% on dry weight basis. Similar magnitude of critical limit of 5.5 mg S g^{-1} in the vegetative plant tissue of Brassica species has been reported by Haneklaus & Schnug (1994).

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EFFECT OF PLANT POPULATION AND FERTILITY LEVELS ON GROWTH AND NPK UPTAKE BY SWEET CORN (*ZEA MAYS* L.) CULTIVARS

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ABSTRACT

A field experiment was conducted during *kharif* 2001 and 2002 to study the effect of plant population and fertility levels on growth and NPK uptake by sweet corn (*Zea mays* L.) cultivars. Test cultivars did not significantly differ in respect of growth parameters, yield and nutrient uptake. Plant population at 55 thousand/ha gave significantly higher dry matter accumulation at harvest. However, successive increase in plant population densities from 55 thousand to 75 thousand/ha recorded significantly higher plant height, number of leaves per plant at tasseling stage, leaf area, leaf area index, green cob yield and NPK uptake by crop were recorded with the application of fertilizer up to 90 kg N + 45 kg P_2O_5/ha.

Key words : Sweet corn, plant population, fertility levels, cultivars, nutrient uptake, yield.

Improved cultivars, adequate plant stand and optimum plant nutrition have the profound bearing on growth, yield and nutrient uptake of maize. However, the relevant research on these aspects in sweet corm is lacking. Keeping this point in view, the present investigation was undertaken.

MATERIALS AND METHODS

A field experiment was conducted at the Instructional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur during *kharif*, 2001 and 2002. The soil of the experimental site was clay loam in texture and alkaline in reaction (pH 7.8). It was medium in available nitrogen (277.24 kg./ha) and available phosphorous (18.98 kg/ha) and high in available potassium (365.64 kg/ha). The experiment was laid out in randomized block design with four replications. Sweet corn cultivars JKSCH-211, Maduri and Mahi Kanchan were used as test cultivars, there plant population (55, 65 and 75 thousand plants/ha) and three fertility levels (60 : 30, 90 : 45 and 120: 60 kg N : P_2O_5/ha) were the other treatments of experiment. The full dose of phosphorus and one-third of nitrogen was applied through DAP and urea at sowing by drilling in furrows at 5 cm below the seeding depth. The remaining two-third of nitrogen was applied through urea as top dressing in two equal splits, at knee-high and initiations of tasseling stage of crop growth.

RESULTS AND DISSCUSSION

Growth characters

The results indicated that the test cultivars had no significant effect on dry matter accumulation, plant height, leaves per plant at tasseling stage and leaf area index at harvest (Table 1).

Plant population at 55 thousand plants/ha produced significantly higher dry mater accumulation per plant at harvest over 75 thousand plants/ha. While, population at 75 thousand plants/ha recorded significantly higher plant height, leaves per plant at tasseling stage, leaf area index per plant over 55 thousand plants/ha. Number of leaves per plant at tasseling stage and leaf area under 75 thousand plants/ha were observed at par with density of 65 thousand plants/ha (Table 1). The significant increase in plant height with increased population densities seems to be the result of mutual shading due to more number of plants per unit area. Mutual

Table 1. Effect of cultivar, plant population and fertility level on growth characters (Pooled data of 2 years)

Treatments	Dry matter accumulation (g/plant)	Plant height at harvest (cm)	Leaves/plant at tesseling stage	Leaf area index
Cultivar				
Mahi Kanchan	106.62	193.25	9.53	3.44
JKSCH-211	104.55	190.74	9.23	3.39
Madhuri	105.47	192.64	9.35	3.42
CD (P=0.05)	NS	NS	NS	NS
Plant population (plants/ha)				
55000	108.75	186.89	9.02	2.79
65000	105.62	191.94	9.43	3.43
75000	102.28	197.80	9.65	4.03
CD (P=0.05)	3.24	5.27	0.30	0.07
Fertility level (N : P_2O_5 kg/ha)				
60 : 30	92.94	171.10	8.40	3.07
90 : 45	111.54	201.36	9.81	3.57
120 : 60	112.17	204.16	9.89	3.61
CD (P=0.05)	3.24	5.27	0.30	0.07

shading due to increased population might have reduced the availability of light within the crop canopy and accelerated the elongation at lower internodes resulting in increased plant height. This observation is in agreement with the statement of Donald (1963), who opined that in most crops, upto a certain level of population, plant elongate rapidly due to mutual shading. Increased plant height with increasing plant population has also been reported by Bhargava *et al.* (1989).

Increasing population densities from 55 thousand to 75 thousand plants/ha decreased dry matter production per plant at harvest. The observed inverse relationship between high density and dry matter production seems to be on account of increased competitive interaction among the plants for want of various growth factors i.e., nutrients and solar radiation. The results are in close agreement with the findings of Hari *et al.* (1995). Leaf area index at harvest significantly increased at population of 75 thousand plants/ha over 55 thousand plants/ha. The improvement in leaf area index with increasing plant density is believed to be on account of reduced space/plant at one hand and presumably increased number of plants/unit area on the other hand. The results are in conformity with the findings of Singh and Srivastava (1991).

Application of 90 kg + 45 kg P_2O_5/ha level recorded significantly higher growth characters viz., dry matter accumulation, plant height, leaves per plant at tasseling stage, leaf area and leaf area at harvest over 60 kg N + 30 kg P_2O_5/ha level but was found at par with application of 120 kg N + 60 kg P_2O_5/ha levels. Profound influence of balanced and increased fertilization comprising combination of N and P on crop growth seems to be due to congenial nutritional environment of plant system on account of their greater availability from soil, which confirms the views of Mullins *et al.* (1999) and Verma (2003).

Yield

The test cultivars were observed at par with each other in respect of green cob yield (Table 2).

Increasing population density from 55 thousand to 75 thousand plants/ha recorded significant increase in green cob yield. Population at 75 thousand plants/ha produced the highest green cob yield of 76.98 q/ha which was higher by 5.9 and 14.9 per cent over 65 thousand and 55 thousand plants/ha, respectively. Increased green cob yield with increasing number of plants, upto

Table 2. Effect of cultivar, plant population and fertility levels on yield and nutrient uptake by crop (Pooled data of 2 years)

Treatments	Green cob yield (q/ha)	Total nitrogen uptake (kg/ha)	Total phosphorus uptake (kg/ha)	Total potassium uptake (kg/ha)
Cultivar				
Mahi Kanchan	73.27	100.92	15.90	102.71
JKSCH-211	71.16	97.46	15.42	99.98
Madhuri	72.19	99.97	15.76	101.71
CD (P=0.05)	NS	NS	NS	NS
Plant population (plants/ha)				
55000	66.98	86.99	13.82	88.57
65000	72.67	100.10	15.81	102.14
75000	76.98	111.26	17.46	113.69
CD (P=0.05)	2.20	4.17	0.67	3.38
Fertility level (N : P_2O_5 kg/ha)				
60 : 30	63.22	83.94	13.04	88.73
90 : 45	76.58	104.76	16.68	106.94
120 : 60	76.83	109.66	17.36	108.73
CD (P=0.05)	2.20	4.17	0.67	3.38

75 thousand/ha suggesting that at this level inter and intra-plant competition could compensate the shading effect on crop canopy. The results are in conformity with the findings of Ameta (1993).

Varying fertility levels significantly affected green cob yield. Application of 90 kg N + 45 kg P_2O_5/ha level produced significantly higher green cob yield over 60 kg N + 30 kg P_2O_5/ha level but was found at par with 120 kg N + 60 kg P_2O_5/ha (Table 2). Application of 120 kg N + 60 kg P_2O_5/ha and 90 kg N + 45 kg P_2O_5/ha gave significantly higher green cob yield by 21.5 and 21.1 per cent, respectively over 60 kg N + 30 kg P_2O_5/ha level. The higher yield realization of sweet corn with application of balanced and higher level of plant nutrition could be ascribed to its profound influence on vegetative and reproductive growth of the crop. Raja (2001) also reported the positive response of maize crop to combined application of nitrogen and phosphorus.

Nutrient uptake

Maize cultivars did not significantly differ with regard to NPK uptake by the crop at harvest (Table 2). Significant increases in NPK uptake by crop were found under increasing population density from 55 thousand to 75 thousand plant/ha at harvest (Table 2). These significant increases in uptake of nutrients with increasing population could be attributed entirely to increasing green cob yield and green fodder yield. The overall increase in biomass with increased number of plants seems to have compensated negative effect of increased population on nutritional status in the plant parts. It is well established fact that accumulation of nutrients is largely depended upon drymatter and the concentration at cellular level. The concomitant improvement in these components under higher plant densities ultimately reflects in higher accumulation of nutrients. The findings are in close accordance with findings of Gaur *et al.* (1991).

Application of 120 kg N + 60 kg P_2O_5/ha was found at par with 90 kg N + 45 kg P_2O_5/ha and these fertility levels gave significantly higher NPK uptake over 60 kg N+30 kg P_2O_5/ha level at harvest. The nutrient uptake by the crop is largely dependent on total biomass production and concentrations of nutrient. The full and super optimal dose of N and P and balance fertilization could have increased biomass production contributing to the uptake of nutrients by the crop. The results are in close conformity the findings of Totawat *et al.* (2001).

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EFFECT OF NAPHTHALENE ACETICA ACID, UREA AND ZINC SULPHATE ON FRUIT DROP AND QUALITY OF BER (*ZIZYPHUS MAURITIANA* LAMK)

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ABSTRACT

Ber is an indigenous and common fruit on India. It is mainly cultivated in arid and semi-arid areas of tropical and sub-tropical parts of the country. Ber is one of the most delicious and nursing fruit and is rich source of vitamin C. protein and mineral. Heavy fruit drop is a main problem in ber which may be due to several factors like moisture stress, root damage, nutritional factor, hormonal imbalance, wind velocity, insect pest and diseases. Therefore, studies were undertaken at CCS Haryana Agcitultural University to ascertain the effect of NAA, urea and zinc on fruit drop and quality of ber cv. Umran. Umran is an important ber cultivar due to high yield and more income per unit area. Three levels of NAA (10, 20 and 30 ppm) and level of urea and zinc (1.5 and 0.5%), respectively and their different combinations were applied as foliar spray two times. The first spray was given in the last week on November and second spray was given in the last week of December on 17 year old ber trees planted at 10x10 m apart. The fruit drop reduced significantly with NAA 10 ppm (34.80%) followed by NAA 20 ppm (36.17%) and urea 1.5% + 0.5% $ZnSO_4$ (38.68%) whereas it was highest in control (48.20%). All the treatments increased the fruit weight and size. Maximum length and breadth was observed with NAA 30 ppm + 1.5% urea. Increased TSS was observed in the treatments NAA 20 ppm + 0.5% $ZnSO_4$.

Key words : Naphthalene, acetic acid, $ZnSO_4$, fruit drop, ber.

Ber (*Zizyphus mauritiana* Lamk) is an indigenous and common fruit of India. It can be cultivated under wide range of climatic conditions. It is mainly cultivated in arid, semi arid areas of the tropical and subtropical parts of the country. Ber is one of the delicious and nourishing fruit and is a rich source of vitamin C, protein and minerals. Among various ber cultivars, Umran is being preferred by fruit growers due to high yield and more income per unit area. Heavy fruit drop is a main problem in ber, which may be attributed to several factors like moisture stress, root damage, nutritional factor, hormonal imbalance, wind velocity, insect pest and diseases etc. Pre-harvest fruit drop may also occur due to formation of an abscission layer due to natural exhaustion of growth regulators present in the fruits. Singh and Vashishtha (1997) observed that tree sprayed with zinc sulphate, borax and urea had higher fruit retention, yield and quality. Foliar application of various growth regulators, macro and micro nutrients are reported to reduce the fruit drop and improve the quality in various fruit crops as reported by Singh *et al.* (1994). Keeping in view, the present studies were conducted for the evaluation of NAA, urea and zinc sulphate for the control of fruit drop in ber.

MATERIALS AND METHODS

An experiment was carried out during 2000-2001 at the Department of Horticulture, CCS Haryana Agricultural University, Hisar. Seventeen years old ber trees of cultivar Umran planted at 10 x 10m apart. Trees sprayed with NAA 10 ppm, 20 ppm, 30 ppm, 1.5 per cent urea and 0.5 per cent $ZnSO_4$ alone and in their combination. Two sprays were given, first in the last week of November and second in the last week of December on the same plants. Number of fruits were counted on selected shoots before spray. The per cent fruit drop was calculated on the basis of number of fruit counted before spray and number of fruit harvested. Fruit length and breadth of randomly selected fruits were measured with the help of vernier caliper. Their average was worked out and expressed in centimeters. For total soluble solids (TTS), pulp of the fruits were randomly selected from composite sample and crushed for extracting juice. TSS was measured with the help of hand refractometer (0-32° Brix) and expressed as per cent total soluble solids.

Results and Discussion

The data given in Table 1 showed that maximum fruit drop percent was found on 15th December (13%) followed by 15th February (9.31%) and minimum on 5th January (3.86%). Minimum (34.80%) fruit drop was recorded in the treatment NAA 10 ppm followed by NAA 20 ppm (36.17%) and maximum (48.20%) in control. The significant reduction in fruit drop percent was found with the foliar application of NAA (10 and 20 ppm), NAA 10 ppm + 1.5% urea, NAA 20 ppm + 1.5% urea, NAA 10 ppm + 0.5% $ZnSO_4$, NAA 20 ppm + 0.5% $ZnSO_4$, NAA 10 ppm + 1.5% urea + 0.5% $ZnSO_4$, urea 1.5%, $ZnSO_4$ 0.5% and urea 1.5% +0.5% $ZnSO_4$ over control. Maximum fruit drop was found on 15th December followed by 15th February and 5th March. This might be due to shriveling of fruits and severe initial competition for nutrients, embryo degeneration (Singh *et al.* 1991). It was observed that NAA alone and in combination with urea and zinc decreased fruit drop at low concentration in present studies. These results are in conformity with the findings of Kedar and Gopal Krishna (1976). Similarly decreased in fruit drop with low concentration of NAA might be attributed to the prevention of abscission layer formation. In addition, the beneficial effect of urea in reducing the fruit drop may be due to its role in improving the plant vigour, thereby increasing the food reserve which serves the fruit till harvest. These results are in conformity with the findings of Chauhan and Gupta (1985) in ber. Decrease in fruit drop with $ZnSO_4$ (0.5%) spray might be due to more availability of photosynthates and this chemical is also associated with harmone metabolism which promote synthesis of auxin leading to diminishing fruit drop as reported by Brahamchari *et al.* (1997).

It is clear from the Table 2 that maximum fruit length (4.53 cm) was observed in fruit

Table 1. Effect of naphthalene acetic acid, urea and zinc on fruit drop (%) in ber

Treatment	Total fruit drop (%)					
	15 Dec.	5 Jan.	25 Jan.	15 Feb.	5 March	Total
NAA 10 ppm	9.17	3.71	4.34	7.15	7.43	34.80
NAA 20 ppm	10.90	3.40	6.59	5.84	9.36	36.17
NAA 30 ppm	12.19	2.85	7.70	9.17	12.07	43.98
NAA 10 ppm + 1.5% urea	13.03	3.80	6.21	11.66	7.25	41.95
NAA 20 ppm + 1.5% urea	10.76	4.88	9.19	8.02	10.70	43.55
NAA 30 ppm + 1.5% urea	10.68	4.78	8.48	12.27	9.10	45.31
NAA 10 ppm + 0.5% $ZnSO_4$	13.50	4.00	4.83	7.17	8.23	37.82
NAA 20 ppm + 0.5% $ZnSO_4$	10.09	6.70	5.60	9.66	10.58	42.63
NAA 30 ppm + 0.5% $ZnSO_4$	13.52	5.20	6.45	9.87	9.09	44.23
NAA 10 ppm + 1.5% urea + 0.5% $ZnSO_4$	14.31	2.64	4.52	7.09	11.96	40.52
NAA 20 ppm + 1.5% urea + $ZnSO_4$	13.71	4.27	7.56	8.93	9.86	44.33
NAA 30 ppm + 1.5% urea + $ZnSO_4$	18.00	2.93	6.14	8.78	10.02	45.87
Urea 1.5%	14.89	2.94	5.55	10.19	5.32	38.89
$ZnSO_4$ 0.5%	11.81	2.13	6.98	10.13	11.74	42.70
Urea 1.5% + 0.5% $ZnSO_4$	13.33	2.70	4.01	10.81	7.83	38.68
Control	18.21	4.88	6.09	12.30	6.72	48.20
Mean	13.00	3.86	6.26	9.31	9.20	
CD at 5%	NS	NS	NS	5.24	NS	4.23

Table 2. Effect of naphthalene acetic acid, urea and zinc on average fruit length and breadth (cm) and TSS (%) of ber

Treatment	Average fruit length (cm)	Average fruit breadth (cm)	Total soluble solids (%)
NAA 10 ppm	4.24	3.25	14.68
NAA 20 ppm	4.24	3.35	15.93
NAA 30 ppm	4.41	3.22	15.63
NAA 10 ppm + 1.5% urea	4.38	3.27	13.66
NAA 20 ppm + 1.5% urea	4.35	3.23	14.00
NAA 30 ppm + 1.5% urea	4.53	3.49	15.80
NAA 10 ppm + 0.5% $ZsSO_4$	4.31	3.46	14.13
NAA 20 ppm + 0.5% $ZsSO_4$	4.27	3.23	16.30
NAA 30 ppm + 0.5% $ZsSO_4$	4.47	3.28	15.90
NAA 10 ppm + 1.5% urea + 0.5% $ZnSO_4$	4.30	3.36	13.56
NAA 20 ppm + 1.5% urea + 0.5% $ZnSO_4$	4.28	3.33	13.80
NAA 30 ppm + 1.5% urea + 0.5% $ZnSO_4$	4.43	3.26	13.80
Urea 1.5%	4.41	3.32	14.00
$ZnSO_4$ 0.5%	4.29	3.25	15.00
Urea 1.5% + 0.5% $ZnSO_4$	4.36	3.20	13.76
Control	4.23	3.19	12.36
C.D. at 5%	0.17	0.16	2.22

treated with NAA 30 ppm + 1.5% urea closely followed by NAA 30 pmm + 0.5% $ZnSO_4$ (4.47 cm) and minimum in control (4.23 cm). Fruit breadth was recorded maximum (3.49 cm) in NAA 30 ppm + 1.5% urea treated fruits and it was closely followed by NAA 10 ppm + 0.5% $ZnSO_4$ (3.46 cm) and minimum in case of control. The possible reason for enhancement in size with spray of NAA might have raised the auxin level in fruit which ultimately helped in the development of its various components as there is direct correlation between auxin content and fruit growth in several plants. Wismer *et al.* (1995) reported increase in fruit size with NAA due to a consequence of cell size in apple. Secondly increase in size might be due to the foliar feeding of nutrients and consequently rapid fruit development caused by easy availability of nutrients to plants. Similar results were observed by Ahmad *et al.* (1998) in guava. TSS content of fruits presented in Table 2 indicated that maximum TSS of fruits (16.30%) was observed in NAA 20 ppm + 0.5% $ZnSO_4$ treated fruits and it was closely followed by NAA 20 ppm (15.93%), NAA 30 ppm + 0.5% $ZnSO_4$ (15.90%) and minimum (12.36%) in control. The increase in TSS might be due to auxin synthesis which in turn increase the metaboloties available for TSS formation. Secondly, due to the formation of more soluble components and synthesis of metabolite and their rapid translocation from other parts of plants to developing fruits. Kamble and Desai (1995) also observed similar results in ber.

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STUDIES ON ABIOTIC FACTORS RELATED TO YIELD GAPS ACROSS THE ENVIRONMENT IN TROPICAL MAIZE (*ZEA MAYS* L.)

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Abstract

The field experiment was conducted at three locations *viz.*, Karnal, Gorakhpur and Bulandshahr during *kharif* and *rabi* season of 2003-04 and 2004-05. Three hybrid cultivars Seed Tech 2324, Bio-9681 and Pro-311 use of common for all the three locations and two local cultivars were chosen from the popular varieties at particular locations. Result revealed that *rabi* maize at Karnal location increased maximum productivity. Among the various cultivars, hybrid maize Seed Tech 2324 produced the highest yield attributes yield of grain and net return per hectare and net return per rupee also.

Key words : Abiotic factors, yield gaps, tropical maize.

Maize (*Zea mays* L.) is one of the most important cereal crop in the world agriculture economy and both food for human beings and feed for animals. It has own importance due to inherent high yield genetic potential and even there is no cereal on the earth which has so immense potentially that is why it is community refereed to as "Queen of Cereal", maize on a global basis ranks third after wheat and rice in respect of area and production. It contributes more than 50 per cent towards the total food grains production in the world. It is an important stable food crop in areas inhabited by tribal and rural poor Indian. In recent years, it has been gaining popularity as an in industrial crop for its numerous products and by products. Albert maize is mainly used as food and fodder by the rural production in India, it possesses a vast industrial potentially having as many as 500 different uses (Rao, 1983). It can be used for manufacturing starch, alcohol, acetic acid lactic acid, syrup, vinegar, resin power, fuel, for torpedoes, artificial leather, boot polish, etc. the green cob are roasted and consumed by the people with great interest. Maize grains are milled into broken grits for making grovel for human consumption. The cropped area under maize during the year 2003-04 was 7.42 million hectare with and production 14.72 million tonnes and productivity 1983 kg/ha, respectively DMR 2003-2004.

Yield of hybrids maize subsequently higher than yield of composites and local cultivars on average, hybrid levels were 2 to 3 times higher than those of local varieties and 1.5 times higher than those composites. Maize yields during the winter season were higher than yields during the rainy season. On average, the difference was upto 1.0 tonnes/ha for hybrids and 5.0 tonnes/ha for local varieties. In this region, maize production is gradually shifting from the rainy to winter season, when the crop is grown mainly under irrigation so that yield levels are higher and cost are lower.

Materials and Methods

The field experiment was conducted at three locations *viz.*, Karnal, Gorakhpur and Bulandshahr during *kharif* and *rabi* seasons of 2003-04 and 2004-05. The soil was sandy loam in texture, low in organic carbon, medium in available nitrogen and phosphorus and high in available potassium with slightly alkaline soil (7.4) in 2003-04 and 2004-05, respectively. The experiment was laid out in factorial randomized block design with five replications. Three cultivars i.e., Seed Tech. 2324, Bio-9681 and

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Pro-311, used for experiment were common for all the three locations and this cultivars were chosen from the popular varieties at particular location. The experimental plot received a basal dose of 60 kg P_2O_5, 40 kg K_2O and 25 kg $ZnSO_4$ per hectare in the form of single superposphate, potassium chloride and zinc sulphate respectively, while nitrogen @ 120 kg/ha was supplied through urea in three equal split at sowing, knee height and tasellling stages of the crop. Maize were sown at a spacing of 75 cm x 25 cm in the ridges of 5 cm deep. A light irrigation was applied just after sowing, later irrigation were given at required intervals depending upon the crop water requirement and weather condition adopting check basin method in both the years of experimentation.

RESULTS AND DISCUSSION

Effect of seasons

Plant height of maize crop increased significantly at flowering stage in *kharif* season as compared to *rabi* season in both the years. Between the season (*kharif* and *rabi*) evaluated for their performance rabi sown maize produced significantly higher number of cobs per plot, cob girth, cob length and number of grain per row per cob and least weight in respective years than the *kharif* maize. *Kharif* maize took significantly lesser number of days to attain 50 per cent silking than *rabi* sown maize. There was delay in days to silking with rabi sown maize. *Kharif* maize attended days to 50 per cent silking earlier because of prevalence of higher maximum and mean temperature compared to *rabi* sown maize. Similar findings were reported by Mishra *et al.* (2002). *Rabi* sown maize produced the highest grain yield (56.00 q/ha in 2003-04 and 61.30 q/ha in 2004-05), which was 8.89 and 16.98 per cent higher in 2003-04 and 2004-05 than the *kharif* sown maize.

Rabi sown maize took more number of days to physiological maturity. The grains in *rabi* sowing must have reached full capacity sink size and must have resulted into bolder and heavier grains ultimately increased grain yield.

Effect of locations

Among the various locations, highest plant height was recorded at Karnal and the least plant height was in Bulandshahr during both the years. Locations (Karnal, Gorakhapur, Bulandshar) did not differ significantly in number of cobs per plot in both the years of the study. However, the number of cobs per plot was highest (208.82) in 2003-2004 at Karnal and (215.78) in 2004-05 at Bulandshahr. Cob length differed significantly among the locations. Cob length (17.46 cm in 2003-04) and 16.87 cm in 2004-05, significantly higher in Karnal than the Gorakhpur and Bulandshahr. Cob girth did not influence due to different locations in 2003-04. Locations Gorakhpur and Bulandhsahr being at par recorded cob girth significantly lower than that of Karnal in 2004-05. Among various locations, Karnal recorded the highest cob girth (15.76 and 16.55 cm) during both the years. Number of grains per row/cob and test weight (100 grain weight) differed remarkably due to locations. Karnal and Gorakhpur being at par recorded significantly more number of grains per row and test weight than that Bulandshahr various locations differed each other in days 50% anthesis and 50% silking during both the years. Among various locations, Karnal recorded the location Karnal took more days in 50% anthesis and 50% silking than that other locations at various locations, yield of the maize crops (t/ha) remained unaffected in 2003-04. While yield was differed in 2004-05, respectively. Locations Gorakhapur and Bulandshahr being at par recorded significantly lower grain yield than the Karnal. Among the various locations, Karnal recorded highest grain yield (54.50 q/ha in 2003-04 and 64.40 q/ha in 2004-05) than the other locations in both the years.

Effect of the cultivar

All hybrid cultivars (P-311, Seed Tech-2324 and Bio-9681) being at par produced significantly higher plant height over local cultivars. Among various cultivars of maize, Pro-311 recorded the highest and local cultivars recorded the least plant height in both the years.

Number of cobs per plot was not differ significantly in both the years. Hybrid cultivars, Pro-311, Seed Tech-2324, Bio-9681 being at par recorded significantly higher cob girth than the local cultivars. Similar results were noticed Feil

Table 1. Plant height, 50% anthesis, 50% silking and number of cobs per plot

Season	Plant height (cm)		Days taken 50% anthesis		Days taken 50% silking		No. of cobs per plot	
	2003-2004	2004-05	2003 - 04	2004-05	2003 - 04	2004-05	2003 - 04	2004-05
Seasons								
Kharif	181.45	178.63	52.45	52.77	54.59	54.94	201.64	209.36
Rabi	162.04	160.82	103.12	125.76	132.33	128.06	213.57	219.45
C.D. (P=0.05)	5.41	4.93	0.55	0.84	0.91	1.04	1.67	1.80
Location								
Karnal	177.80	175.66	91.68	91.80	93.82	94.14	208.82	214.40
Gorakhpur	172.49	171.11	91.44	88.20	93.68	90.46	205.34	215.78
Bulandshahr	166.31	162.42	90.74	87.80	92.92	89.92	208.66	213.04
C.D. (P=0.05)	6.56	6.09	0.68	1.02	1.12	1.27	NS	NS
Cultivar								
Seed Tech - 2324	180.13	177.46	91.06	89.16	92.12	91.36	204.06	216.43
Bio-9681	179.74	177.35	90.86	89.10	93.14	91.43	207.40	213.76
Pro-311	178.63	174.38	91.46	89.40	93.59	91.66	208.90	214.06
Local Check -1	160.84	154.48	91.76	89.40	93.99	91.56	208.56	212.06
Local Check-2	165.05	161.97	91.26	89.26	93.29	91.50	209.10	215.10
C.D. (P=0.05)	8.21	7.80	NS	NS	NS	NS	NS	NS

Table 2. 100-grain weight, number of grain per row, cob length, cob girth and yield t/ha

Season	100-grain weight (g)		No. of grains in row/cob		Cob girth (cm)		No. of cobs per plot		Yield (q/ha)	
	2003-2004	2004-05	2003 - 04	2004-05	2003 - 04	2004-05	2003 - 04	2004-05	2003 - 04	2004-05
Seasons										
Kharif	24.05	25.11	29.84	29.80	16.20	15.49	14.75	14.82	51.40	52.40
Rabi	27.53	28.86	32.95	32.36	16.84	16.81	16.67	16.50	56.00	61.30
C.D.(P=0.05)	1.55	1.39	1.20	0.94	0.50	0.40	0.55	0.44	3.50	2.70
Location										
Karnal	27.29	28.70	32.67	32.86	17.16	16.87	15.76	16.55	54.50	64.44
Gorakhpur	25.10	27.09	31.53	31.02	16.66	16.28	15.75	15.37	53.90	55.00
Bulandshahr	24.38	25.17	29.99	29.35	15.73	15.30	15.62	15.07	52.70	51.10
C.D. (P=0.05)	1.84	1.71	1.47	1.18	0.62	0.50	NS	0.54	NS	NS
Cultivar										
Seed Tech - 2324	27.78	29.06	34.68	34.53	18.10	17.71	16.72	16.70	70.90	72.70
Bio-9681	27.49	29.50	31.85	31.75	16.71	16.43	16.21	16.36	58.40	62.40
Pro-311	28.08	29.43	31.33	31.40	16.24	16.34	15.91	15.99	53.40	57.80
Local Check -1	22.21	22.70	31.46	30.47	15.70	15.36	15.17	14.95	42.40	44.80
Local Check-2	23.39	24.24	27.65	27.23	15.86	14.91	14.53	14.31	43.50	46.80
C.D. (P=0.05)	2.45	2.21	1.89	1.49	0.89	0.64	0.88	0.71	5.60	4.20

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et al. (1992). Among the different cultivars hybrid cultivar Pro-311 produced the significantly, higher cob length per cob and number of grains per row of cob compared to rest of the cultivars. Mishra *et al.* (2002) observed higher cob girth and cob length with hybrid cultivars. Test weight (100 seed weight) of maize crop was significantly higher with all the hybrid cultivars over the local cultivars during both the years different cultivars hybrid and local did not differ significantly in 50% anthesis and in 50% silking during both the years of investigation. Maize cultivars differed each other with respect to grain yield. All the hybrid cultivars were significantly superior with respect to grain yield per hectare. Hybrid cultivars seed Tech. 23-24 and Bio-9681 being at par produced significantly lower grain yield than the hybrid Pro-311 in both the years. Both local cultivars being at par produced significantly lower grain yield than that of all hybrid cultivars during both the years. Freitas *et al.* (2001) recorded higher grain yield per hectare with hybrid cultivars than local cultivars.

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INFLUENCE OF PHOSPHORUS AND ORGANIC MANURE ON YIELD AND QUALITY OF LATE SOWN RAPESEED (*BRASSICA CAMPESTRIS VAR* TORIA) UNDER RAINFED CONDITION

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Abstract

A field experiment was conducted during the *rabi* seasons of 2001-2002 and 2002-2003 at Imphal to evaluate the effect of phosphorus and organic manure on rapeseed. The highest seed yield, oil content and oil yield was associated with the application of phosphorus at 60 kg P_2O_5/ha. Addition of organic manure irrespect of the sources showed higher seed yield as well as oil yield over control. Among the sources of organic manure application of poultry manures at 5t/ha indicated the highest yield of seed and oil. Significantly higher uptake of phosphorus both in seed and stover were recorded with the application of 60 kg P_2O_5/ha and poultry manure. Residual available phosphorus in soil was benefited by the application of 60 kg P_2O_5/ha. Addition of poultry manure also enhanced the post harvest available nitrogen and phosphorus in soil.

Key words : Rapeseed, phosphorus, organic manure, seed and oil yield, nutrient uptake, post harvest available nutrient.

Rapeseed is one of the important *rabi* crops of Manipur. It is sown during the month of December after the harvest of *kharif* paddy. The average productivity of this crop in the state is 707 kg/ha as against the national average of 982 kg/ha. There is ample scope to raise the productivity of this oil seed crop in the state through proper agrotechniques, of which nutrient management is important. Among the major nutrients, phosphorus is the most limiting nutrient for increasing the productivity in the acid soil of Manipur. On the other hand with the ever increasing cost of the chemical fertilizer and deteriorating soil health, it is necessary to identify the most suitable organic manure for balanced fertilization of the crop. The use of organic manure will not only meet the plant nutrient demand but also improve the physical properties of the soil. Hence, the present investigation was undertaken.

Materials and Methods

A field experiment was conducted during the *rabi* seasons of 2001-2002 and 2002-2003 at College of Agriculture Farm, Central Agricultural University, Imphal. The soil of the experimental field was clay in texture, acidic in reaction (pH 5.5), high in organic carbon (2.2%), high in available nitrogen (480 kg/ha), medium in available P (40 kg P_2O_5/ha) and high in available K (420 kg K_2O/ha). The experiment was laid out in the factorial randomized block design with three replication. The treatments consisted of four levels of phosphorus and three sources of manure. The variety TS-29 was sown on 12th November and 15th November in 2001-02 and 2002-03, respectively. Seeds were sown in rows 30 cm apart and plants were thinned to 10 cm 15 days after sowing. A uniform dose of 20 kg/ha each of N (1/2 dose) and K_2O (Full dose) along with phosphorus as per treatment were given basally. Remaining half dose of N (20 kg/ha) was top dressed 50 days after sowing. Farm yard manure and poultry manure @ 5 t/ha were incorporated 15 days before sowing as per treatments. The crop was harvested on 21st March, 2002 and 24th March, 2003, respectively. The total rainfall received during the cropping season of 2001-2002 and 2002-2003 were 116.4 mm and 188.5 mm, respectively.

Table 1. Effect of phosphorus and organic manure on yield attributes, yield and quality of rapesed (Mean of 2 years)

Treatment	No. of silique/plant	No. of seeds/siliqua	1000 seed weight (g)	Seed yield (q/ha)	Oil content (%)	Oil yield (q/ha)
Levels of phosphorus (kg/ha) (kg/ha)						
0	70.8	14.3	2.7	6.5	33.9	2.2
20	77.9	14.7	2.7	6.8	34.0	2.9
40	78.6	15.1	2.7	7.2	34.7	3.0
60	85.4	15.3	2.8	7.7	35.7	3.1
CD (P=0.05)	0.3	0.3	NS	0.03	0.1	0.02
Sources of organic manure (5t/ha)						
0	56.4	13.6	2.7	5.8	32.8	2.0
FYM	75.2	15.2	2.7	7.1	34.3	2.4
Poultry manure	102.5	15.7	2.8	8.1	36.6	4.0
CD (P=0.05)	0.2	0.2	NS	0.03	0.1	0.02

Table 2. Effect of phosphorus and organic manure on phosphorus uptake and post harvest residual nutrients (Mean of 2 year)

Treatment	P-uptake (kg/ha)		Residual soil nutrient (kg/ha)		
	Seed	Stover	N	P_2O_5	K_2O
Levels of phosphorus (kg/ha)					
0	3.7	1.7	480.4	40.8	420.1
20	3.9	1.8	481.3	43.0	420.4
40	4.2	2.0	482.2	44.7	420.5
60	4.5	2.1	482.8	45.8	420.8
CD (P=0.05)	0.2	0.1	NS	0.8	NS
Sources of organic manure (5t/ha)					
0	3.3	1.5	479.6	36.7	419.9
FYM	4.1	1.9	481.8	44.7	420.4
Poultry manure	4.8	2.3	483.6	49.3	421.0
CD (P=0.05)	0.1	0.1	2.3	0.7	NS

RESULTS AND DISCUSSION

Yield attributes and yield

Application of phosphorus significantly increased all the yield attributes except 1000 seed weight. Maximum number of silique per plant and seeds per siliqua was obtained with the application of 60 kg P_2O_5/ha. The seed yield increased significantly with every increase in the level of phosphorus and the maximum was recorded in 60 kg P_2O_5/ha (Table 1). Such positive yield response of phosphorus application is obvious when it is deficient in the soil. The soil sample analyzed before the start of the experiment also showed that the available phosphorus status was in the medium range. Application of phosphatic fertilizer therefore provides better nutrition to the crop resulting in higher seed yield. The beneficial influence of phosphorus application on yield attributes and seed yield was also reported by Patel and Shelke (1998) and Bhari *et al.* (2000). Application of organic manure irrespective of sources significantly increased the seed yield over the control. However, the maximum seed yield was recorded with the addition of poultry manure at 5t/ha. The higher seed yield obtained in this treatment may be attributed to more number of silique per plant as well as number of seeds per silique. Further, it may be ascribed to congenial physical soil condition when organic manure is applied besides supplying both macro nutrients. Similar finding was reported by Bury (1996) and Patel and Shelke (1998).

Oil content of seed and oil yield

Phosphorus application significantly increased the oil content of seed and the maximum was recorded at 60 kg P_2O_5/ha. Synthesis of fatty acids in plant occurs through conversion of acetyl CO-A in presence of ATP and phosphate. The higher oil content could be attributed to formation of more lecithin, a from of phospholipids, favored by phosphorus application. The higher oil yield recorded in this treatment is the resultant effect of higher oil content as well as seed yield. Arthamwar *et al.* (1996) and Patel and Shelke (1998) also reported such favorable effect of phosphorus on oil content and yield. The application of organic manure irrespect of the source, significantly increased the oil content and oil yield of seed over control. This might be due to synthesis of more glycosides, which increase the oil content. Higher seed yield with the addition of poultry manure might have resulted in higher oil yield. The result is in conformity with that of Patel and Shelke (1998) and Shankar *et al.* (2002).

Phosphorus uptake

Phosphorus uptake by seed and stover significantly increased with increasing levels of phosphorus upto 60 kg P_2O_5/ ha (Table 2). This can be explained by the fact that the increase in the supply of limiting nutrient not only increased the phosphorus concentration in plant but also resulted in higher dry matter production expressed in terms of seed and stover yield which ultimately resulted in higher phosphorus uptake. Tomer *et al.* (1997) also reported that increase in the fertility level increased the phosphorus uptake in Indian mustard. The maximum uptake of phosphorus was recorded with the application of poultry manure. This might be due to higher dry matter accumulation recorded with poultry manure application. The result is in conformity with the findings of Rao and Shaktawat (2002).

Soil fertility status

Enhanced availability of residual phosphorus in soil was recorded with the application of phosphorus upto 60 kg P_2O_5/ ha. This finding confirms the earlier report of Singaram and Kothandaram (1993). Application of organic manure significantly increased the residual available nitrogen and phosphorus. This might be due to release of nitrogen and phosphorus after decomposition of organic manure. It also could be attributed to the greater multiplication of soil microbes, which could covert organically bound nitrogen into inorganic form. This confirms the earlier results of Bhardwaj and Omanwar (1994). The increased residual available phosphorus might be due to increased solubility of native phosphorus with the addition of organic manure. Further, organic materials form a cover on sesquioxide and thus reduces the phosphorus fixing capacity of soil. Similar opinion was expressed by Subehia and Minhas (1993).

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STUDY ON YIELD AND YIELD COMPONENT TRAITS IN CHICKPEA (*CICER ARIETINUM L.)*

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ABSTRACT

Fifty-six *desi* and *kabuli* chickpea (*Cicer arietinum* L.) genotypes were evaluated for yield component traits along with six cultivated varieties as checks, viz., Pusa 72, Pusa 256, Pusa 262, Pusa 272, Pusa 1003, and Pus 1053. Significat variation was observed for number of primary branches, number of secondary branches, plant canopy height, plnat canopy width, days to 50% flowering, flowering duration, number of pods per plant, number of seeds per pod, yield and 100-seed weight. Correlation studies indicated significant positive correlation between grain yield on one hand and number of primary branches (r=0.77) and biological yield (r=0.70) on other hand. These characters can be utilized for indirectly selecting high yielding genotypes.

Key words : Chickpea, desi and kabuli, corelation, yield, yield component traits.

Chickpea (*Cicer arietinum* L.) is the third most important pulse crop in the world after beans (*Phaseolus vulgaris*) and peas (*Pisum sativum*). But its poor productivity makes in non -competitive in comparison to present day high yielding varieties of cereals. The average productivity of chickpea is still below one ton per hectare, wihich is considered low by any standards.

One of the inherent limiting production problems in gram is the limited biomass under most conditions. If the total biomass is low then little can be achieved by better partitioning of vegetative and reproductive growth (Singh, 1986). There is a need to increase biomass, harvest index and yield potential.

As yield is a very coplex character depending on number of component characters, the knowledge of the association between the yield and its components and among the components themselves is of imense practical value in making selections. Therefore, the primary step in this direction will be a quantitative assessment of the available variability in respect of yield and its components.

MATERIALS AND METHODS

The material for the present study comprised of 71 desi and kabuli genotypes of chickpea. These genotypes were collected from the world wild species germplasm collection of ICRISAT, Patancheru in 2003. Seeds of 71 chickpea genotypes wee raised in single row in a screen house and multiplied in an observation nursery during rabi season in 2003-04. The study also included 6 cultivated varieties of chickpea as checks collected from the Division of Genetics, IARI, New Delhi. They were Pusa 72, Pusa 256, Pusa 362 and Pusa 372 (desi type) ; Pusa 1003 and Pusa 1053 (kabuli type). Out of 71 genotypes, 15 genotypes were not considered for evaluation because of very poor performance with respect to germination, growth and seed setting.

During rabi season of 2004-05, seeds fo 56 out of 71 genotypes were sown in an Augmented Randomized Complete Block Design (ARCBD) (Federer, 1956). The design consisted of 4 blocks/replications. A spacing of 30 cm between two rows and 10 cm between plants within a wo was followed. Five representative plant were randomly taken for each genotype for recording data for different yield and yield contributing characters (IBPGR, ICRISAT and ICARDA descriptors 1993). The statistical analysis of the data was carried out using a microcomputer based program called AUGMENT 1 (Agrawal and Sapra, 1995). The following yield and yield component traits were studid : Number of primary branches, number of secondary

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Table 1. ANOVA and range for yield and yield component traits of checkpea genotypes

Characters	F Values	Mean range Min. value	Mix. value	Genotypes with desirable mean value
Number of primary branches	2.68*	2.0	4.7	ICC 337
Number of secondary branches	2.94*	7.5	27.0	ICC 12439
Plant canopy height (cm)	4.10**	35.3	72.75	ICC 8920
Plant canopy width (cm)	5.66**	26.8	57.0	ICC 12434
Days to 50% flowering	3.87**	58	92	ICC 12432, ICC 12434
Flowering duration (days)	2.76*	19	39	ICC 12434
Days to maturity	1.88	135	154	ICC 60, ICC 337, ICC 12424, ICC 12432
Number of pods per plant	3.50**	9.0	64	ICC 337
Number of seeds per pod	5.87**	1.0	2.0	ICC 5156, ICC 11052, ICC 11303, ICC 12440
Biological yield (q/ha)	2.24*	23.3	103	ICC 915
Grain yield (q/ha)	2.67*	2.0	36.2	ICC 915
100-seed weight (g)	4.76**	8.644	50.16	ICC 7344

*, ** = significant at 5% and 1% level, respectively.

branches, plant canopy height, plant canopy width, days to 50% flowering, flowering during, days to maturity, number of pods per plant, number of seeds per pod, biological yield, grain yield and 100-seed weight.

RESULTS AND DISCUSSION

The evaluated genotypes have shown significant variation for plant characters like number of primary branches, number of secondary branches, plant canopy height and plant canopy width. Highly significnat variation was observed for inflorescence and fruit characters like days to 50% flowering, flowering duration, number of pods per plant, number of seeds per pod, grain yield and biological yield, among the evaluated chickpea genotypes. There was significant variation for 100-seed weight among the evaluated genotypes (Table 1). Association studies (Table 2) indicated significant positive correlation between number of primary branches on one hand number secondary branches, days to 50% flowering, number of pods per plant and seed yield on the other hand. This is because, as number of primary branches increases, naturally secondary brances would increase resulting in more vegetative growth of the plant. Accumpulation of biomass takes more time resulting in delayed flowereing. But, number of pods per plant was increased as thre may be increased photosythate due to more biomass. Similarly the number of secondary branches has shown positive association with the number of primary branches, pods per plant, biological yield and grain yield. Plant canopy height and plant canopy width have shown significantly positive association between them (Table 2). In other words genotypes with more plant height tend to be spreading in their growth habit while dwarf genotypes tend to be erect in their growth habit.

Correlation studies (Table 2) indicated negative association between days to 50% flowering and flowering duration. In other words, early flowering genotypes had more floering duration.

Table 2. Correlation coefficients for yield and its component traits

r	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
X1	1.00	-0.84**	0.07	-0.02	0.18	0.38**	0.26	0.20	0.03	0.22	0.14	-0.18
X2	-0.84**	1.00	-0.00	0.15	-0.015	-0.32*	-0.12	-0.10	0.02	-0.04	-0.00	0.06
X3	0.07	-0.00	1.00	0.53**	0.31*	-0.12	-0.01	-0.05	-0.22	0.06	-0.15	0.17
X4	-0.02	0.15	0.53**	1.00	0.16	-0.09	0.13	0.11	-0.12	0.23	0.14	-0.10
X5	0.18	-0.00	0.31*	0.16	1.00	-0.019	0.15	0.03	0.06	0.58**	0.13	0.44**
X6	0.38**	-0.32*	-0.12	-0.09	-0.19	1.00	0.34*	0.29*	-0.1	0.24	0.38**	-0.03
X7	0.26	-0.12	-0.01	0.13	0.15	0.034*	1.00	0.65**	0.22	0.55**	0.51**	-0.13
X8	0.20	-0.10	-0.05	0.11	0.03	0.29*	0.65**	1.00	0.36*	0.56**	0.77**	-0.29*
X9	0.03	0.02	-0.22	-0.12	0.06	-0.01	0.22	0.36*	1.00	0.20	0.17	-0.30*
X10	0.22	-0.04	0.06	0.23	0.58**	0.24	0.55**	0.56**	0.20	1.00	0.70**	0.10
X11	0.14	-0.00	-0.15	0.14	0.13	0.38**	0.51**	0.77**	0.17	0.70**	1.00	-0.07
X12	-0.8	0.06	-0.17	-0.10	0.44**	-0.03	-0.13	-0.29*	-0.30*	0.10	-0.07	1.00

X1=Days to 50% flowering
X3= Plant canopy height
X5= Day to maturity
X7=Number of secondary branches
X9=Number of seeds per pod
X11=Grain yield
r= correlatio coefficient

X2= Flower duration
X4=Plant canopy width
X6 = Number of primary branches
X8=Number of pods per plant
X10= Biological yield
X12= 100-seed weight (test weight)

There was no correlation between days to 50% flowering and yield. Days to maturity was found to be positively correlated with plant canopy height, biogical yield and 100-seeds. This may be due to availability of more time for seed filling and maturation. Significant positive association was observed between number number of pods per plant on one hand and number of branches, number of seeds per pod and yield on the other hand. Negative association was observed between number of pods per plant and number of seeds per pod on one hand and 100-seed weight on the other hand. In other words, as the number of pods per plant and seeds per pod increased the seed size becomes smaller, and smaller. Biological yield has shown positive association with number of secondary branches, number of pods per plant, days to maturity and grain yield. Therefore, these factors can be used for indirect selection of the genotypes for higher biomass and high yield potential.

Correlation between characters could be due to linkage or pleiotropy. Correlation due to linkage can be modified through recombination, but correlation due to pleiotropy or developmental causes may not be easy to overcome. Knowledge with respect to association of various traits with seed yield would be of immense help in formulation an effective and efficient selection and screening programme.

In the present investivgation, significant positive correlation between grain/seed yield on one hand and number of primary branches, number of secondary branches, number of pods per plant and biological yield on the other hand was observed. Therefore, to increase the yield potential of chickpea, the breeding strategy should be to increase number of branches, number of pods per plant and the biological yield. Similar results have been reported by Fillipetti (1990), Kharat et al (1991), Dasgupta *et al.* (1992), Singh *et al.*(1995) , Rao *et al.* (1994), Berger and Turner (2000), Vijayalakshmi *et al.* (2000), Sable *et al.* (2002) and other workers. The results justified the observation of Singh (19 86) that if the biomass is low, then little can be achieved by better partitioning.

Three genotypes were found to be having vary high 100-seed weight viz. ICC 7344 (50.16g), ICC 11303 (41.8g) and ICC 4854 (40.75g). As no significant association between yield and 100-seed weight was observed, it is possible to (Table 2) observed between 100-seed weight and days to maturity reflects that late maturing genotypes have larger seeds.

Current study has indicated significant variation among the genotypes for evaluated yield component traits. Association studies have indicated number of branches, number of seeds per pod and biological yield to be very useful for selecting for higher yield.

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CHEMICAL WEED CONTROL IN TRANSPLANTED RICE (*ORYZA SATIVA*) IN HIRAKUD COMMAND AREA

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Abstract

A field experiment was conducted during the rainy seasons of 2002 and 2003 on transplanted rice at Chiplima, Orissa to evaluate the efficiency of herbicide mixture of almix and butachlor to control both grasy and broad leaved weeds. Application of almix 0.004 kg mixed with butachlor 0.938 kg/ha at 3 days after transplanting (DAT) was as good as hand-weeding twice at 20 and 40 DAT in controlling weeds and achieving grain yield. Application of almix 0.004 kg + butachlor 0.938 kg/ha increased the grain yield by 45.1% over the unweeded check. There was a negative linear relationship between weed dry weight and grain yield.

Key words : Transplanted rice, chemical weed control, herbicide mixture, weed control efficiency.

Unlike other cereal crops, rice suffers more from weed competition. Yield loss due to uncontrolled weed growth in transplanted rice ranges from 16 to 86% (Aurora and DeDatta, 1992). In order to realize maximum benefit of applied monetary inputs, weed control at critical stage of crop-weed competition is inevitable. Hand weeding is commonly followed to control weeds in this crop. However, continuous rains during cropping season, scarcity and high wages of labour, particularly during peak period and early crop-weed competition make this operation difficult and uneconomic. Different herbicides are thus used alone or in combination to eliminate weeds but their efficiency differ because of their narrow spectrum of weed control. Application of herbicide mixtures is useful, particularly in the absence of an effective broads-spectrum herbicide in rice to control highly diverse population of weed flora, consisting of grasses, broad leaved weeds and sedges (Rao and Singh, 1997). The present study was undertaken to evaluate the effectiveness of butachlor and almix both as a mixture and sequential application to control weeds in transplanted rice in Hirakud command area of western Orissa.

Materials and Methods

A field experiment was conducted at Chiplima during rainy season (*kharif*) 2002 and 2003. The soil of the experimental field was sandy clay loam with pH 6.6, organic carbon 0.43% and available N ($KMnO_4$ method), P (Olsen) and K (NH_4OHC method) content of 268, 13.4 and 132 kg/ha, respectively. The experiment consisting of 11 treatments (Table 1) was laid out in randomized block design with 3 replications. Rice cultivar 'Lalat' maturing in 125 days was the test crop. Thirty days old seedlings were transplanted during the third week of July in both the years, with a spacing of 15 cm x 15 cm. A common fertilizer dose of 80, 40 and 40 kg of N, P_2O_5 and K_2O/ha respectively was applied. Full dose of P_2O_5 and K_2O and half dose of N were applied as basal and remaining N was top-dressed in 2 equal splits, at maximum tillering and panicle-initiation stages of the crop. Plant protection measures and irrigations were provided as and when required. The required quantity of herbicides were applied with manually operated knapsack sprayer using a spray volume of 500 liter water/ha. A thin film of water was maintained in the field at the time of application of herbicides.

Table 1. Effect of herbicides on yield components and yield of transplanted rice (pooled data of 2002 and 2003)

Treatment	Dose (kg/ha)	Time of application (DAT)	Maximum tillers /m²	Panicles /m²	1000 grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	B:C ratio
T_1, Butachlor (Machete)	1.5	5	389	320	21.8	4.19	5.59	1.20
T_2, Butachlor (MON 46996)	1.5	5	330	294	20.7	4.07	5.47	1.17
T_3, Fentrazamide	0.15	4	359	300	21.0	4.15	5.52	1.33
T_4, Fentrazamide	0.12	4	372	311	21.3	4.31	5.96	1.35
T_5, Pyrazosulfuron-ethyl	0.02	8	339	290	21.9	4.49	6.26	1.36
T_6, Pyrazosulfuron-ethyl	0.025	8	348	298	22.3	4.59	6.39	1.35
T_7, Almix + Butachlor (Machete)	0.004+0.938	3	401	341	22.8	4.92	6.50	1.66
T_8, Butachlor (Machete) fb Almix	0.938 fb 0.004	3 fb 25	392	330	22.8	4.75	6.20	1.64
T_9, Weed free check			414	348	23.4	5.20	7.12	1.61
T_{10}, Two hand weeding		20 fb40	382	321	23.4	5.05	6.65	1.64
T_{11}, Non-weeded control			315	270	21.4	3.39	4.06	0.65
CD ($p = 0.05$)			31.6	17.9	NS	0.20	0.24	

fb, followed by (applied sequentially); +, tank mixed; DAT, days after transplanting

Weed counts (numbers/m²), weed dry weight (g/m²) were sampled randomly at 2 places with the help of 0.25 m² quadrate at 60 days and at harvest. Weed population data were analyzed after subjecting to square root transformation. Yield and yield attributes of rice were recorded at crop harvest. Weed control efficiency was also calculated on the basis of dry matter production of weeds.

RESULTS AND DISCUSSION

Weed flora

Major weed flora in the experimental field consisted of grasses *Digitaria sanguinalis* (L.) Scop., *Echinochloa crus-galli* (L.), *Echinochloa colonum* (L.) Link, *Panicum repens* (L.) ; sedges *Cyperus difformis* (L.), *Cyperus iria* (L.), *Cyperus rotundus* (L.), *Fimbristylis miliacea* (L.) Vahal and broad-leaved weeds (BLW) *Ammania baceifera* (L.), *Ludwigia paraviflora* (L.), *Eclipta prostrata* (L.), *Eclipta alba* (L.), *Lippa nodiflora* Nich, *Marsilea quadrifolium* (L.), *Sphenoclea zeylanica* Gaertn., *Commelina benghalensis* (L.) and *Leptochloa chinensis* (L.). The composition of grasses, sedges and broad-leaved weeds in weedy check plot was 27.2, 36.8 and 36.0% respectively. Emergence of broad-leaved weeds was noticed earlier as compared to sedges and grasses.

Effect on weed flora

Weed density and weed dry weight were higher at 60 days after transplanting (DAT) than at harvest. This was perhaps due to death of some of the seeds like *Digitaria sanguinalis, Echinochloa colonum, Cyperus difformis, Marsilea quadrifolium* and *Commelina benghalensis* and the shanding effect of the tall weeds like *Echinochloa crusgalli* and crop plants on short - stature weeds. Similar results were also recorded by Rao and Singh (1997).

At both the stage of observation unweeded check recorded significantly higher weed population and dry weight than any other treatment (Table 2). Two hand-weedings at 20 and 40 days after transplanting (DAT) recorded the minimum weed population and dry weight and the highest weed control efficiency at both the stages. Among the herbicidal treatments, application of tank mixture of almix 0.004 kg and butachlor (Machete) 0.938 kg/ha at 3 DAT recorded the minimum weed population and dry weight and the highest weed control efficiency

Table 2. Effect of herbicides and herbicide mixtures on weed population and weed biomass in transplanted rice (pooled date of 2002 and 2003)

	Weed population/m^2						Total weed dry weight (g/m^2)		WCE (%)	
	60 DAT			at harvest			60 DAT	at harvest	60 DAT	at harvest
	Grass	Sedge	BLW	Grass	Sedge	BLW				
T_1	3.3 (10.4)	4.4 (18.6)	4.4 (19.0)	2.9 (8.3)	3.9 (15.2)	3.8 (14.2)	45.9	38.7	57.7	61.7
T_2	2.9 (8.4)	4.6 (20.3)	4.3 (18.2)	2.8 (7.6)	4.3 (17.6)	3.9 (15.3)	51.6	43.3	52.4	57.2
T_3	5.2 (26.2)	3.8 (14.2)	4.3 (17.8)	4.8 (22.3)	3.5 (12.1)	3.4 (11.6)	32.9	28.6	69.7	71.7
T_4	4.8 (22.1)	3.6 (12.5)	4.4 (19.2)	4.3 (17.7)	3.2 (10.0)	3.3 (10.2)	30.6	24.8	71.8	75.5
T_5	5.1 (25.7)	3.3 (10.1)	3.7 (13.6)	4.9 (23.6)	2.9 (8.2)	3.2 (10.0)	34.8	30.3	67.9	70.0
T_6	5.2 (27.0)	3.1 (9.5)	3.6 (12.5)	4.6 (21.2)	2.7 (6.8)	2.9 (8.2)	30.2	23.6	72.1	76.7
T_7	3.6 (12.3)	3.0 (9.0)	3.4 (11.4)	3.3 (10.7)	2.5 (6.0)	2.8 (7.40	21.7	16.6	80.0	83.6
T_8	3.8 (14.2)	3.4 (11.1)	3.7 (13.5)	3.5 (12.0)	2.8 (7.6)	2.9 (8.1)	28.8	22.9	76.2	77.5
T_9	0.7 (0)	0.7 (0)	0.7 (0)	0.7 (0)	0.7 (0)	0.7 (0) -	-	-	-	
T_{10}	3.6 (12.2)	3.8 (14.0)	3.3 (10.3)	2.7 (7.1)	3.1 (9.3)	3.1 (9.2)	18.4	15.6	83.0	84.6
T_{11}	8.5 (72.3)	9.3 (86.4)	9.8 (94.6)	8.2 (67.0)	9.5 (90.7)	9.4 (88.6)	108.6	101.3	-	-
CD (p=0.05)	1.38	1.21	1.31	1.25	1.46	1.321	3.9	3.5		

Figures in parentheses are original values; DAT: days after transplanting; BLW: broad leaved weeds ; WCE: weed control efficiency

(Table 2). This treatment was followed by sequential application of butachlor 0.938 kg at 3 DAT followed by almix 0.004 kg/ha at 25 DAT. The reduced weed - control properties exhibited by the herbicide mixtures. Unweeded control plot recorded the highest weed population and dry weight.

Among the herbicidal treatments, application of butachlor 1.5 kg/ha at 5 DAT recorded the highest weed population and dry weight and lowest weed control efficiency, indicating its ineffectiveness.

Effect on crops

All the herbicidal treatments significantly influenced panicles/m^2, filled grains/panicle, grain and straw yields compared with unweeded check (Table 1). However, 1000-seed weight was not significantly influenced by treatments. The highest grain yield was recorded with weed free check which was closely followed by two hand weedings at 20 and 40 DAT. Among the herbicides, application of almix 0.004 kg mixed with butachlor (Machete) 0.938 kg/ha at 3 DAT recorded significantly higher grain yield than all other treatments and this treatments was comparable with two hand weedings. The hand weeding twice, application of almix 0.004 kg mixed with butachlor (Machete) 0.938 kg/ha at 3 DAT increased the grain yield by 49.0 and 45.1%, respectively over the unweeded check. The increased grain yield in these treatments were owing to reduced weed density, weed dry weight and better weed control efficiency (Table 2), higher panicles/unit area and grains/panicle (Table 1). The minimum yield and yield attributes in unweeded check were results of severe weed competition by the uncontrolled weed growth. Straw yield followed almost similar trend as that of grain yield. Narwal *et al.* (2002) also reported increased grain yield by herbicide mixtures. Application of almix 0.004 kg mixed with butachlor 0.938 kg/ha recorded the maximum benefit : cost ratio indicating the high economic returns.

Regression analysis indicated that there was significant negative linear relationship between grain yield and weed dry weight at 60 DAT. The simple linear regression Y=5.07 - 0.0164 X was obtained from pooled data where Y is the expected grain yield (t/ha) and X is the observed weed dry weight (g/m^2) at 60 DAT. The correlation coefficient 'r' value was - 0.88 indicating a high degree of negative correlation between weed dry weight and grain yield. Rao and Singh (1997) also observed negative linear relationship between weed dry weight and grain yield in transplanted rice.

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EFFECT OF IRRIGATION SCHEDULES AND NITROGEN LEVELS ON THE GRAIN YIELD OF MAIZE IN ALFISOLS OF NSP LEFT CANAL COMMAND AREA

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ABSTRACT

A field trial was conducted on irrigation schedules and nitrogen levels in maize grown on light red sandy soils of A.R.S., Garikapadu during *rabi* 1999-2000 to 2001-02 in split plot design. The treatments consisted of four irrigation schedules (0.6, 0.8, 1.0 IW/CPE ratio and 5 irrigations at crop phenological stages in main plots and 5 nitrogen levels (0, 60, 120, 180 and 240 N kg/ha) in sub plots. Grain yield, WUE and nitrogen use efficiency and water requirement were worked out. Maximum grain yield was recorded when the irrigation was scheduled at 1.0 IW/CPE and nitrogen fertilized upto 240 kg/ha.

Key words : Maize, irrigation schedules, IW/CPE ratio, N-Levels, WUE.

Maize (*Zea mays* L.) is one of the principal cereal crops after rice in Andhra Pradesh cultivated in an area of 3.5 lakh hectares. Though the crop is mainly grown as rainfed crop during *kharif* season, it is also being cultivated as a irrigated crop during *rabi* season. In the recent years, the crop occupied large area in Krishna, Guntur and Godavari districts as an alternate crop to rice under irrigated conditions during *rabi* season. In view of the limited irrigation water availability in the canals, coupled with discouraging of growing of rice during *rabi* season, the crop assumes much importance under Nagarjuna Sagar Left Canal Command comprising Nalgonda, Khammam and Krishna districts. Much information is not available on irrigation schedules and nitrogen fertilization in this crop grown under NSP left command. The soils in the command are light textured with low to medium nitrogen status. Hence, the present experiment was initiated to workout the optimum irrigation schedule and nitrogen levels for *rabi* maize grown under light soils of NSP left command.

MATERIALS AND METHODS

A field study was carried out for 3 years on scheduling of irrigation and nitrogen fertilization to maize during *rabi* season 1999-2000 through 2001-2002 at Agricultural Research Station, Garikapadu, Krishna district of Andhra Pradesh on sandy loam soils. The decennial average rainfall was 830 mm and evaporation ranged from 2000 to 2200 mm. The soils were near neutral in reaction with pH ranging from 6.5 to 7.5 and non-saline (EC 1.0 to 1.5 dS/m). Available N, P and K in the experimental site ranged from 119 -173, 18-27 and 135-207 kg/ha, respectively. The field capacity and infiltration rate ranged from 15.5 to 17.5% and 2.25 cm/hr, respectively. The rainfall received during crop growth period varied between 6.0 mm to 73.4 mm. The experiment consisted of 4 irrigation schedules in main plots and 5 nitrogen levels in sub-plots laid out in split-plot design in 3 replications. The variety used was DHM-107 (90-100 days duration) during *rabi* 1999-2000 and Cargill hybrid (110-120 days duration) during *rabi* 2000-2001 and 2001-2002. It was sown at 75cm x 20 cm spacing. A basal dose of 60 kg/ha P_2O_5 and 30 kg/ha K_2O, were applied in the form of single super phosphate and muriate of potash. Whereas, the nitrogen was applied through urea in three equal splits as basal and at knee-high and flowering stages. The method of irrigation was through check basin. In each irrigation, 50 mm of water was given with the help of parshall flume. A pre-sowing irrigation of 50 mm was given to all the treatments as a common irrigation. Other management practices such as weed control and pest management etc. were taken up as per recommended practices. The water requirement was worked out as per the following equation *viz.* Water Requirement = Irrigation water applied + Rainfall received. Open pan evaporation data was used for calculating IW/CPE ratio for treatments T_1 to T_3. Water use efficiency (WUE) was worked out based on the yield obtained and total water applied during crop growth period i.e., yield (kg/ha)/amount of water applied (mm). The nutrient utilization of applied N was studied in terms of agronomic efficiency i.e. a ratio between amount of grain produced and the amount of nutrient applied. The yield data was analyzed through standard statistical tools for interpretation.

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RESULTS AND DISCUSSION

The results of the study clearly indicated that the maize grain yield was significantly influenced by the irrigation schedules and nitrogen levels. However interaction effect between irrigation regimes and N-levels was significant only during *rabi* 1999-2000.

Irrigation schedules and crop yield

Maximum maize grain yield of 2662 and 4706 kg/ha was recorded when irrigation was scheduled at 1.0 IW/CPE ratio in 1999-2000 and 2000-01, respectively and found significantly superior over other treatments. Hussaini *et al.* (2002) have also reported that irrigation at 1.0 IW/CPE produced significantly higher maize yield. During 2001-02, irrigations given at 5 different physiological stages recorded maximum grain yield (6076 kg/ha.) This was closely followed by irrigation scheduled at 1.0 IW/CPE (5748 kg/ha) and found superior over rest of the treatments. On the other hand, in all the years of study, significantly lowest yield (1538, 3329 and 5069 kg/ha) was recorded when the irrigation was scheduled at 0.6 IW/CPE ratio. In terms of total depth of water applied, highest

Table 1. Effect of irrigation schedules and nitrogen levels on the grain yield of maize

Treatments	Yield (kg/ha)				WUE (kg/ha/mm)	Agronimic efficiency (kg/grain/kg N applied)
	1999-2000	2000-2001	2001-2002	Mean		
Irrigation (I)						
I_1-0.6 IW/CPE	1538 (250mm)	3329 (250mm)	5069 (250mm)	3312 (250mm)	13.5	-
I_2-0.8 IW/CPE	1915	4211	5460	3862	12.18	-
I_3-1.0 IW/CPE	2662 (350mm)	4706 (350mm)	5748 (350mm)	4372 (350mm)	11.91	-
I_4- K+T+S+M+D	2230 (300mm)	3963 (350mm)	6076 (350mm)	4090 (350mm)	13.63	-
CD at 5%	381	471	470	-	-	-
N levels (kg/ha) (N)						
N_1-0	931	743	1162	945	-	-
N_2-60	1655	3507	5315	3492	-	42.45
N_3-120	2153	4900	6540	4531	-	29.88
N_4-180	2614	5417	7163	5065	-	22.98
N_5-240	3076	5694	7760	5510	-	19.0
CD at 5%	188	591	537	-	-	-
IXN	S	NS	NS	-	-	

Figures is parenthesis are depth of water applied in mm including one pre-sowing irrigation
K-Knee high, T-Tasseling, S-Silking, M-Milk and D-Dough
S : Significant ; NS : Not significant

Table 2. Interaction effect of irrigation schedules and nitrogen levels on maize yield during *rabi* 2000

Irrigation/Nitrogen	N_0	N_{60}	N_{120}	N_{180}	N_{240}
I_1-0.6 IW/CPE	810	1302	1597	1857	2125
I_2-0.8 IW/CPE	738	1565	1958	2356	2958
I_3-IW/CPE	1103	2042	2773	3375	4012
I_4-K+T+S+M+D	1075	1713	2282	2870	3208

CD for N levels at the same level of irrigation -337
CD for irrigation at same level of N levels-453

quantity of water (367 mm) by the treatment of 0.6 IW/CPE. Maximum WUE (13.63 kg/ha.mm) was observed in the treatment which received irrigations at 5 different physiological stages.

Nitrogen levels and crop yield

A significant difference in the maize grain yield was observed due to different N-levels. Maximum grain yield (3076, 5694 and 7760 kg/ha in 1999-2000, 2000-01 and 2001-02, respectively) was recorded at 240 kg N/ha and found significantly superior over other N-levels tried except in the year 2000-01 where the grain yield (5417 kg/ha) recorded at 180 kg/ha N was found to be on par with 240 kg/ha N. Significantly lowest yield was observed in the control plot. Ghadiri and Majidian (2003) reported the highest maize grain yield at 276 kg N/ha.

Maximum agronomic efficiency of applied N (42.45) was observed when the maize was fertilized at 60 kg N/ha. The response gradually decreased with the increased nitrogen from 60 kg to 240 kg/ha.

Irrigation and nitrogen levels

Interaction effect between irrigation schedules and N-levels were significant in the year 1999-2000. The response to increased doses of N-levels was more at irrigation scheduled at 1.0 IW/CPE as compared to lower frequency of irrigation i.e. at 0.6 IW/CPE. Highest grain yield of 4012 kg/ha was obtained at 1.0 IW/CPE (350 mm depth of water) and at N-level of 240 kg/ha. Irrigation scheduled at IW/CPE of 0.80 to 1.00 coupled with 140-250 kg N/ha provided optimum maize yield and WUE as reported by Al Kaisi and Yin (2003).

Based on the 3 years study results it can be concluded that for obtaining maximum maize grain yield, the crop should be irrigated at 1.0 IW/CPE with 240 kg N/ha. However, when water availability is limited, the best way of irrigation and nitrogen fertilization for optimum yield, was irrigation at knee-high, tasseling, silking, milk and dough stages with 120-180 kg of N/ha under light soils of Nagarjuna Sagar Left Canal Command area.

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RESPONSE OF HYBRID RICE TO THE APPLICATION OF NITROGEN MAGNESIUM AND BORON

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ABSTRACT

Response of nitrogen, magnesium and boron along with the recommended dose of phosphorus, potassium were studied on hybrid rice (ProAgro 6201) through a field experiment laid out in split plot design for two consecutive years (2001 and 2002) at Research farm, Department of Agronomy, BHU, Varanasi. Increasing rate of nitrogen, magnesium and boron brought about marked improvement in almost all the yield components of hybrid rice with subsequent decrease in sterility percentage. Consequently significant increase in grain yield as well as profitability was recorded due to incorporation of 180 kg nitrogen, 40 kg magnesium and 2 kg boron ha^{-1}.

Key words : Hybrid rice, nitrogen, magnesium, boron, sterility percentage.

A continuous gain in rice grain yield is essential to meet targeted rice requirement of 135-145 million tonnes by 2020 (Subbaiah and Balsubramanian, 2000). For breaking yield barriers, hybrid rice is the only viable option due to its 15-20 per cent more yield potentiality (Siddiq, 2002). However, in most of the areas hybrids have not come up to its yield potential due to high spikelets sterility. Success and sustenance of hybrid rice production through various cost effective agronomic and nutrient management practices is thus vital for the spread of this technology in India. Apart from N which is essential for effective assimilation and consequent filling of grains, boron and magnesium also play significant physiological role in rice in increasing the number of grains set per panicle and thus overcome sterility problem of hybrid rice to realize high potential yield (Subedi *et al.* 1997).

MATERIALS AND METHODS

A field investigation was carried out at the Research Farm, Department of Agronomy, Institute of Agricultural Sciences, BHU, Varanasi during the two consecutive Kharif (rainy) seasons of 2001 and 2002 on sandy loam soil with pH 7.4 medium in available P (20 kg P_2O_5 ha^{-1}), potassium (226 kg K_2O ha^{-1}), magnesium (5.4 cmol (p+) kg ha^{-1}) and boron (0.47 ppm) and low in available nitrogen (182 kg N ha^{-1}) and organic carbon content (0.38 per cent). The treatments consisting of three levels of each nitrogen (60, 120 and 180 kg ha^{-1}), magnesium (0, 20 and 40 kg ha^{-1}) and boron (0, 1 and 2 kg ha^{-1}) were allocated in main, sub and ultimate plots in split plot design with three replications. Urea, DAP, MOP, Magnesium Sulphate, Borax and Zinc Sulphate were used as sources of nutrients. A uniform dose of 75 kg P_2O_5, 60 kg K_2O and 5.25 kg Zinc ha^{-1} applied to all the plots as basal application at transplanting. Nitrogen was applied in three splits, half as basal and remaining half in two equal splits conciding with tillering and panicle initiation stages. The total amount of magnesium and boron was applied in the ratio of 2/3rd as basal and 1/3rd as foliar application of 2 and 4 per cent for magnesium and 0.1 and 0.2 per cent for boron conciding at tillering and flowering stages. Hybrid ProAgro 6201 was transplanted with 30 days old seedlings @ 2 hill^{-1} a spacing of 20 x 15 cm on July 18 and 14 during 2001 and 2002, respectively. The response of hybrid rice to various treatments was measured in terms of yield and yield attributing components like panicle length, grain number panicle^{-1}, sterility percentage and test weight. Profitability was worked out on the basis of grain and straw yield.

RESULTS AND DISCUSSION

Effect of nitrogen

Application of 180 kg N ha^{-1} significantly decreased the grain sterility per cent and increased filled grains $panicle^{-1}$ over 120 kg N (Table 1). The per cent increase in filled grains $panicle^{-1}$ due to application of 180 kg N ha^{-1} was 37.72 and 31.77 and 12.30 and 9.05 per cent higher than 60 and 120 kg N ha^{-1} during 2001 and 2002, respectively. Application of 180 kg N ha^{-1} recorded significantly higher panicle length, panicle weight and test weight than 120 kg N ha^{-1} and 60 kg N ha^{-1}. Marked improvement in yield attributes may be ascribed due to adequate availability and translocation of N and other nutrients to the sink (Raju *et al.*1992). Adequate assimilation of carbohydrates in the panicle proved instrumental in increasing grain number per panicle. Om *et al.* (1998) also reported similar opinion and obtained higher number of grain $panicle^{-1}$ due to higher N application.

N applied @ 180 kg ha^{-1} produced significantly maximum grain yield and straw yield as well as harvest index (Table 2). The per cent increase in grain yield due to 180 kg N ha^{-1} was recorded 11.18 and 6.27 per cent higher than 120 kg N ha^{-1} and 37.02 and 31.06 per cent higher over 60 kg N ha^{-1} during 2001 and 2002, respectively. Higher levels of N, brought about significant increase in grain yield were due to marked improvements in yield attributes with pronounced reduction in grain sterility percentage. These results are strongly supported by Om *et al.* 1998. Similarly better vegetative

Table 1. Effect of different levels of nitrogen, magnesium and boron on growth and yield attributes of hybrid rice

Treatment	Panicle length (cm)		Number of grains $panicle^{-1}$		Sterility (%)		Panicle weight (g)		Test weight (g)	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
A. Nitrogen (kg ha^{-1})										
N_{60}	24.7	24.5	144.3	157.1	25.16	29.44	4.05	4.34	19.75	19.96
N_{120}	26.3	26.7	176.5	189.8	20.82	27.89	5.36	5.54	22.61	23.01
N_{180}	27.6	27.9	198.7	206.9	20.43	22.24	6.66	6.18	22.89	23.06
SEd	0.28	0.27	5.37	4.37	1.02	1.19	0.30	0.13	0.54	0.74
CD (P=0.05)	0.78	0.75	14.91	12.13	2.83	3.30	0.83	0.36	1.50	2.05
CV (%)	4.01	6.52	11.49	8.69	16.95	16.44	22.30	9.60	9.19	12.32
B. Magnesium (kg ha^{-1})										
Mg_0	25.7	25.8	161.1	173.6	23.30	27.29	4.89	4.81	20.50	21.06
Mg_{20}	26.3	26.6	173.2	184.9	21.99	26.89	5.46	5.58	22.19	22.47
Mg_{40}	26.5	26.6	185.1	195.4	21.12	25.39	5.72	5.67	22.57	22.50
SE d	0.24	0.23	4.75	4.14	0.91	1.05	0.21	0.13	0.45	0.41
CD (P=0.05)	0.52	0.50	10.35	9.02	1.98	2.28	0.45	0.28	0.98	0.89
CV (%)	3.32	4.25	10.16	8.22	15.07	14.59	15.70	9.37	7.57	6.82
C. Boron (kg ha^{-1})										
B_0	25.6	25.9	163.8	175.8	26.35	29.96	4.97	4.83	20.87	21.29
B_1	26.4	26.4	173.1	184.9	22.05	26.86	5.40	5.51	21.69	22.07
B_2	26.6	26.8	182.5	193.1	18.00	22.75	5.69	5.73	22.69	22.67
SE d	0.21	0.21	3.67	3.36	1.01	0.92	0.18	0.12	0.38	0.28
CD (P=0.05)	0.43	0.43	7.44	6.81	2.05	1.86	0.36	0.24	0.77	0.57
CV (%)	2.97	3.28	7.86	6.68	16.83	12.83	13.40	8.53	6.51	4.68

Y_1 : during *kharif* 2001, Y_2 : during *kharif* 2002

Table 2. Effect of nitrogen, magnesium and boron on yield and economics of hybrid rice

Treatment	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})			Harvest index (%)			Economics	
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Net return (Rs. ha^{-1})	B:C ratio
A. Nitrogen (kg ha^{-1})											
N_{60}	50.42	56.01	53.22	66.76	69.51	68.14	43.14	44.71	43.92	16133.51	1.01
N_{120}	62.14	69.08	65.61	73.56	77.56	75.56	45.79	47.10	46.45	22546.28	1.35
N_{180}	69.09	73.41	71.25	78.69	80.16	79.42	46.84	47.85	47.35	25132.73	1.45
SEd	0.79	0.80	0.79	2.43	2.58	2.43	0.84	0.88	0.84	NA	NA
CD (P=0.05)	2.19	2.22	2.19	6.74	7.16	6.75	2.33	2.44	2.33		
CV (%)	4.80	4.44	4.61	12.21	12.50	12.01	6.81	6.92	6.74		
B. Magnesium (kg ha^{-1})											
Mg_0	56.89	61.85	59.37	71.89	74.64	73.27	44.07	45.25	44.66	20093.26	1.28
Mg_{20}	61.15	67.07	64.11	73.49	76.24	74.87	45.38	46.77	46.07	21700.02	1.30
Mg_{40}	63.62	69.58	66.60	73.63	76.35	74.99	46.32	47.64	46.98	22019.25	1.24
SE d	0.68	0.70	0.69	2.21	1.66	1.89	0.78	0.64	0.70	NA	NA
CD (P=0.05)	1.48	1.53	1.50	NS	NS	NS	1.71	1.40	1.53		
CV (%)	4.13	3.90	3.98	11.13	8.05	9.35	6.36	5.08	5.62		
C. Boron (kg ha^{-1})											
B_0	57.06	62.72	59.89	75.68	78.43	77.06	42.89	44.32	43.59	20338.19	1.28
B_1	61.37	66.91	64.14	72.12	74.84	73.48	45.95	47.18	46.56	21648.35	1.30
B_2	63.24	68.88	66.06	71.21	73.96	72.58	46.95	48.17	47.56	21825.99	1.24
SE d	0.49	0.55	0.50	1.59	1.43	1.42	0.60	0.53	0.54	NA	NA
C.D. (P=0.05)	1.00	1.11	1.01	3.22	2.91	2.87	1.22	1.08	1.10		
CV (%)	2.98	3.04	2.88	7.99	6.95	7.00	4.89	4.19	4.33		

Y_1 : during *kharif* 2001, Y_2 : during *kharif* 2002; NS : Non-significant, NA : Not analyzed.

growth of plants due to higher N increased the straw production (Rao *et al.* 1999).

Effect of magnesium

The significantly higher length of panicle, panicle weight, test weight and reduced sterility per cent were recorded due to incorporation of 40 kg Mg ha^{-1} over control, though remained at par with 20 kg Mg ha^{-1}. Association of adequate Mg availability with higher production of protein is well established which not only increased the production of grains but also decreased the unfertile grains. The percentage increase in grain number due to application of 40 kg Mg ha^{-1} was 14.92 and 12.57 and 6.87 and 5.68 over control and 20 kg Mg ha^{-1} during 2001 and 2002, respectively. The findings of Vijaylakshmi and Mathan (1991) also supported this fact.

Accordingly application of 40 kg Mg ha^{-1} produced maximum grain yield and harvest index but remained at per with 20 kg Mg (Table 2). These results are in accordance with Pandey *et al.* (2001). However, no significant impact of Mg was noted on straw yield. It may also be true due to the fact that hybrid rice has higher photosynthetic activity and their grain : straw ratio is often seen higher than that of high yield varieties and supported by Agata (1990).

Effect of boron

Increased boron supply significantly increased the panicle length, panicle weight and subsequently reduced grain sterility percentage over control though remained equally effective with 1 kg B ha^{-1}. The percentage increase in grain number panicle^{-1} due to 2 kg B ha^{-1} was 11.44 and 9.24 over control during 2001 and 2002, respectively. The maximum test weight was recorded due to application of 2 kg B ha^{-1} which proved significantly superior to 1 kg B ha^{-1} during 2001 and 2002, respectively. The B showed marked stimulating effect on protein synthesis and increased panicle length due to effective translocation of carbohydrates and thus decreased sterility percentage and increased the number of grains panicle^{-1} (subedi *et al.*, 1997). Increased yield attributes due to B application was also supported by the findings of Mondal and Rey (1999).

The maximum grain yield and harvest index were recorded due to application of 2 kg B ha^{-1} (Table 2) which proved significantly superior to 1 kg B ha^{-1} as well as control. Both the B levels i.e., 1 and 2 kg B ha^{-1} increased the grain yield by 6.68 and 9.82 and 7.55 and 10.83 per cent over control during 2001 and 2002, respectively. However, straw yield remained unaffected due to B application. Increase in grain yield due to increasing B supply was positively correlated with grain number (Jahiruddin *et al.* 1992). Studies indicated that B required for seed and grain production is little higher than that for vegetative growth.

Economics

Application of 180 kg Nha^{-1} incurred higher total cost but recorded maximum gross return, net return and B:C ratio. Similarly increased supply of Mg (40 kg ha^{-1}) and B (2 kg ha^{-1}) brought about marked increase in gross return and net return mainly due to subsequent increase in grain yield. Maximum B:C ratio was associated with 20 kg Mg ha^{-1} and 1 kg B ha^{-1} which declined with further increase in their levels mainly due to high cost of Magnesium Sulphate and Borax. These findings are in strong corroboration with the findings of Mitra and Jana (1991) and Dutta *et al.* (1993).

Conclusively hybrid rice fertilized with 180 kg N, 20 kg Mg and 2 kg B along with recommended dose of P, K and Zn may be viable option for improving the productivity and profitability of hybrid rice in eastern plain region of Uttar Pradesh.

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ESTIMATION OF HERITABILITY, GENETIC ADVANCE AND VARIABILITY FOR YIELD CONTRIBUTING CHARACTERS IN RICE (*ORYZA SATIVA* L.)

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ABSTRACT

The knowledge of genetic variability in a given crop species for character under improvement is essential for any plant breeding programme. Heritability with genetic advance are more helpful in predicting the gain under effective selection. With four CMS lines, eight testers and thirty two hybrids evaluated for thirteen characters related to yield. Low, moderate and high genotypic and phenotypic coefficient of variations observed. Heritability was high for all the characters with high and moderate genetic advance observed for different characters related to yield.

Key words : Heritability, variability, genetic advance, rice.

Rice contributes around 45 per cent of India's cereal production and is the main staple food for over 60 per cent of the population in country. Despite the age old human concerns about balancing population and food supplies, the world population is expected to continue to grow, possibly reaching 9-11 billion sometimes during 2030-2050. With the current trends of population growth and agricultural production, the demand for food in most parts of world will double by the year2025 and nearly triple by 2050.

The knowledge of genetic variability present in a given crop species for the character under improvement is of paramount importance for the success of any plant breeding programme, Heritability and genetic advance are important selection parameters. Heritability estimates along with genetic advance normally more helpful in predicting the gain under selection than heritability estimates alone.

MATERIALS AND METHODS

The biological material in the present study comprises of four CMS lines used having the WA cytoplasmic background, viz., IR 68885A, IR 62829A, DRR 2A and PMS 10A used as lines and eight promising varieties of rice viz., BKP 232, R 827-287, Pusa Basmati, R 1060-1674-1-1, R 714-2-103, Culture 1001, Super Rice-2 and R 304-24 as testers. Thirty-two hybrids were made using four lines X eight testers in *kharif* 2004 at Research Farm, IGKVV, Raipur.

All the forty four plant material was sown in randomized block design (RBD) with two replications. A standard spacing of 20 x 20 cm, was adopted for planting. Recommended package of practices were followed during the crop growth period. Observations were recorded for thirteen characters related to yield. Genotypic, phenotypic and environmental variance, heritability and genetic advance were estimated for all thirteen characters.

RESULTS AND DISCUSSION

Variability, heritability and genetic advance was estimated as described below:

Variability

Low genotypic coefficient of variations were observed for breadth of paddy, panicle length, length of paddy and days to 50 per cent flowering. Moderate genotypic and phenotypic coefficient of variations were shown by effective tillers shown by effective tillers plant, total number of spikelets per panicle and plant height whereas, high genotypic coefficient of variations were expressed by harvest index, total number of filled spikelets per panicle, 100-grain weight and spikelet fertility percentage. High

Table 1. Analysis of variance for different characters

Source variation	Degree of freedom	Days 50% flowering	Plant height (cm)	Panicle length (cm)	Effective tillers/ plant	Total no.of spikelets/ panicle	Total no. of filled spikelets/ panicle	Total no. of chaffy spikelets/ panicle	Spikelet ferti- lity (%)	100 grain- weight (g)	Harvest index (%)	Length of paddy (cm)	Breadth of paddy (cm)	Grain yield/ plant (g)
Replications	1	4.13	0.06	4.64	4.10	165.5	58.00	17.66	9.19	0.0005	42.94	0.02	0.003	49.48
Treatment	43	75.59*	284.50*	7.17*	6.20*	1517.97*	5767.11*	4284.66*	1982.00*	0.49*	561.31*	0.82*	0.09*	168.49*
Error	43	0.52	1.93	0.40	1.37	363.75	166.72	171.35	20.20	0.02	13.15	0.005	0.003	5.72

Table 2. Genotypic and phenotypic coefficient of variability (gcv and pcv), heritability (h^2), genetic advance and components of variance

	Days 50% flowering	Plant height (cm)	Panicle length (cm)	Effective tillers/ plant	Total no. of spikelets/ panicle	Total no. of filled spikelets/ panicle	Total no. of chaffy spikelets/ panicle	Spikelet fer- tility (%)	100 grain weight (g)	Harvest index (HI)	Length of paddy (cm)	Breadth of paddy (cm)	Grain yield plant (g)
GCV%	6.31	12.94	7.65	17.94	14.90	58.84	63.51	57.06	29.51	67.49	7.08	8.81	60.72
PCV	6.36	13.03	8.09	22.45	19.02	60.53	66.10	57.64	30.72	69.09	7.16	9.13	62.80
Heritability% (Broad base)	98.60	98.70	89.40	63.90	61.30	94.40	92.30	98.00	93.00	95.40	98.70	93.10	93.40
Genetic advance as % of mean	12.91	26.48	14.87	29.53	24.04	117.76	125.70	116.34	58.43	135.79	14.36	18.50	120.86
Genotypic variance (σ^2g)	37.51	141.29	3.39	2.42	577.11	2800.20	2056.66	980.90	0.24	274.08	0.41	0.04	81.39
Phenotypic variance (σ^2p)	38.06	143.22	3.79	3.79	940.86	2962.92	2228.01	1001.10	0.26	287.23	0.42	0.043	87.77
Envirronmental variance (σ^2e)	0.52	1.93	0.40	1.37	363.75	162.72	171.35	20.20	0.02	13.15	0.005	0.003	5.72

phenotypic variations observed composed of high genotypic variations and less of environmental variations, which indicated the presence of high genetic variability for different traits and less influence of environment (Tables 1 and 2). Similar resultw were observed by Kumar *et al.*(1974), Chaubey and Singh (1994), Pathak and Sharma (1996), Sarvanan and Senthil (1997), Rather *et al.* (1998), Satya *et al.* (1999), Shivani and Sreerama Reddy (2000), Iftekharudduala *et al.* (2001) and Sao (2002).

Heritability

High heritability were observed for all the characters studies viz., days to 50 per cent flowering, plant height, panicle length, effective tillers per plant, total number of filled spikelets per panicle, total number of chaffy spikelets per panicle, total number of spikelets per panicle, spikelet fertility percentage, 100-grain weight, harvest index, length of paddy, breadth of paddy and grain yield per plant (Tables 1 and 2). High heritability indicates the scope of genetic improvement of these characters through selection. Similar results have been reported by Panwar *et al.* (1997), Sarawgi *et al.* (2002), Gannamani (2001) and Sao (2002).

Genetic advance

High genetic advance was exhibited by harvest index, total number of chaffy spikelets per panicle, grain yield per plant, total number of filled spikelets per panicle and spikelet fertility percentage. Moderate genetic advance were observed for days to 50 per cent flowering, panicle length, length of paddy and breadth of paddy (Tables 1 and 2). Similar findings also reported by Regina *et al.* (1994), Vannirajan *et al.* (1996), Shivani and Sreerama Reddy (2000), Iftekharuddaula *et al.* (2001), Gannamani (2002).

High heritability with high genetic advance indicated heritability is due to additive gene effects and selection may be effective for related characters.

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BIOASSAY OF SOME PRE-EMERGENCE HERBICIDES IN MUSTARD-*POLYGONUM* ASSOCIATON UNDER *TERAI* AGRO-CLIMATIC SITUATION

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Herbicide bioassay is the method of assaying a herbicide on the basis interaction between the herbicide molecule and a biological entity. Bioassay is being used widely as a useful tool to regulate herbicide doses in particular crop. This technique also leads to identify the herbicides that are safe for a crop in terms of phytotoxicity and growth reduction by relating the different herbicidal doses with the percent reduction in fresh weight of individual plants (Tag *et al.*, 1981).

Non-selective action of the herbicides and their residual toxicity on the established mustard plant observed in field experiment under *terai* agro-climatic region led to the need to find out a herbicide and dose that is safe for use as preeemergence treatment in mustard. There was also a need to understand sensitivity and tolerance of different mustard cultivars against the action of different herbicides. The bioassay experiment was planned to determine the degree of selectivity through the measurement of selectivity index of the herbicide in different cultivars in connection with their sensitivity and tolerance against the action of herbicides and to compute the selectivity index of the herbicides. Field experiments were carried out during the *rabi* season of 2003 in the farm of Uttar Banga Krishi Viswavidyalaya to determine the degree of selectivity of pendimethalin and fluchloralin through the measurement of selectivity index in different varieties of mustard *viz.* B-9, Jhumka and Chaiti (a traditionally grown local cultivar in Cooch Behar) to achieve control on seeds especially *Polygonum* sp the dominanat weed in the *terai* agro-climatic region of West Bengal. The soil of the experimental site was sandy loam with pH 5.8.

In mustard varieties pendimethalin doses of 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 1.0, 1.2 and 1.4, kg a.i./ha and fluchloralin doses of 0, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2 and 2.4, kg a.i./ha were used in the field experiment having a plot size of 1sq m area. In *Polygonum* sp pendimethalin doses of 0.0, 0.05, 0.10, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45 and 0.5, kg a.i./ha and fluhloralin doses of 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.60, 0.7, 0.8, 1.0 and 1.2, kg a.i./ha were used.

Plant samples were taken at 4 days interval after sowing. Visual observations were made everyday to observe the changes in growth behaviour of the plants and appearance of phytotoxic symptoms owing to herbicidal toxicity on plant at different doses. Biological response of plants to herbicides was determined by measuring the fresh weight of the plants grown in herbicide treated soil with different doses.

The response of the mustard varieties and *Polygonum* plants grown with different concentrations of herbicides, were compared with the healthy plants grown in untreated plots. The per cent kill (% kill) values were obtained at these doses. A straight line was obtained through computation of regression equation reflecting response of plants at different doses of herbicides.

The proportional increase of plant response in terms of growth reduction to herbicide dose led to identify the level at which the plant produced 50% response, which is known as GR_{50} (dose that cause 50% growth reduction) or ED_{50} (equivalent dose for 50% response). GR_{50} values show relative sensitivity of some crops to herbicides (Nel *et al.*, 1995).

The results revealed that up to 25% growth reduction of the mustard crop did not have have significant effect on yield as growth suppression was recovered by growth rate at later stage of crop growth. Therefore, it was postulated that maximum dose of herbicide tolerated by the crop for economic cropping will be that dose which will cause 25% reduction on crop vigour at intial stage. Then minimum dose required to control the weeds was dertermined by considering the dose required to suppress the growth of the weed especially *Polygonum* up to 80%, which, in turn, reflect 80% weed control efficiency. Then selectivity index of the herbicides in case of each variety was determined by dividing the maximum dose of herbicide tolerated by the crop with the minimum dose required to control the weeds.

The phytoxic effect to mustard plants was manifested with characteristic yellowing and necrotic symptom that appeared within 7-8 DAS in the leaves of newly emerged seedling. Appearance of yellowing and necrotic symptom was followed by death of seeding that happened within 11-12 DAS. Pedimethalin and fluchloralin have been tried against three mustard cultivars for *Polygonum*-mustard association in the experiment. Low GR_{50} value (dose that caused 50% growth reduction of *Polygonum*) of pendimethalin against *Polygonum* indicated high activity of pendimethalin in controlling *Polygonum* compared to fluchloralin (Table 1). However, the value of selectivity index of pendimethalin measured for *Polygonum*-chaiti and *Polygonum*-jhumka association was equal to 1 indicating the sensitivity of chaiti and jumka to the action of pendimethalin. High sensitivity of chaiti and jhumka made pendimethalin a non-selective herbicide to control *Polygonum* in these cultivars. The cultivar B9 was less sensitive and acquired certain degree of tolerance against lethal effect of pendimethalin. The value of selectivity index for *Polygonum*-B9 association was 1.2, which indicated narrow range of selectivity of pendimethalin for controlling *Polygonum* in B9 (Table 1). Results obtained in the experiment led to understand the fact that pendimethalin ensured selectivity at the dose of 0.3 kg a.i./ha for controlling *Polygonum* in B9, however, it had narrow range of selectivity and slight increase in dose to improve the activity of pendimethalin could destrory the selectivity property. Cultivars showed difference in their response relating to degree of tolerence against the action of fluchloralin, however, all the cultivars became tolerant to the chemical. Among the cultivars B9 had high degree of tolerance to fluchloralin closely followed by chaiti resulted in high value of selectivity index of 1.74 measured for *Polygonum*-B9 and *Polygonum*-chaiti association (Table 1). This indicated the fact that flucholralin had wide range of selectivity for controlling *Polygonum* in B9 and chaiti at the dose of 1.1 and 0.89 kg a.i./ha, respectively. Even though jhumka became less tolerant to fluchloralin compared to B9 and chaiti, the fluchloralin ensured selectivity at dose of 0.79 kg a.i./ha for controlling *Polygonum*.

Among the herbicides fluchloralin had wide range of selectivity and can be applied safely in B9 and chaiti for controlling *Polygonum*. However, jhumka became highly sensitive to pendimethalin and less tolerant to fluchloralin resulted in non-selective action of pendimethalin and narrow range of selectivity in fluchloralin for controlling *Polygonum*.

Table 1. Reggession equation, r^2 value, selectivity index and GR_{50} values of herbicide plant interaction in bioassay experiment

Plant and herbicide	Regression equation	r^2 value	Selectivity index	GR_{50} values
B-9 & fluchloralin	Y=5.4255 X+ 4.2908	0.9693	1.74	1.35
B-9 & pendimethalin	Y=4.3863 X+ 6.6411	0.9082	1.20	0.42
Jhumka & fluchloralin	Y=5.3659 X+4.8908	0.7979	1.36	1.05
Jhumka & pendimethalin	Y4.7609 X+7.2249	0.9424	1.00	0.34
Local variety & fluchloralin	Y=4.7174 X+4.5595	0.9537	1.74	1.24
Chaiti (local variety) & pendimethalin	Y=3.513 X+6.4172	0.9634	1.00	0.26
Polygonum & fluchloralin	Y=2.4256 X + 6.4172	0.9634	-	0.26
Polygonum & pendimethalin	Y=5.423 X+ 9.1328	0.7884	-	0.17

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STUDIES ON ORGANIC FARMING AND INTEGRATED NUTRIENT MANAGEMENT SYSTEM ON PERFORMANCE OF POTATO

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In Chhattisgarh, potato is cultivated in 9,163 hectare with a production of about 49238 metric tonnes. Recently there has been a consciousness about the organic farming for quality products and decreasing the use of inorganic fertilizer to minimize the environmental pollution but without decreasing the productivity of the crops. Thus there is a need to workout the suitable combination of organic and inorganic fertilizers without effecting the yield and quality of crop.

The present investigation was conducted at the Instructional Farm of Indira Gandhi Agricultural University, Raipur during the winter season of 2004-05. The treatments comprised of seven nutrient management practices in potato (*Solanum tuberosum* L.) var. Kufri chipsona. The spacing of potato crop was 60 cm row to row and 30 cm plant to plant. The recommended dose of fertilizer (RDF) was 80 : 50 : 30 kg NPK/ha. The full dose of P and K and half of the N was applied as basal dose. The remaining quantity of N was given in 2 splits at 30 and 60 days after planting respectively. The FYM, crop residues (CCR) and neem cake (NC) were applied as basal dose. The potato tubers were graded after harvesting into two groups as large size (<20 g) and small size (<20g). The experiment was laid out in randomized block design in three replications.

Total number of tubers/plant (<20g) ranged from 6.50 to 10.50 and from 2.00-3.75 in case of tubers <20g with a mean value of 7.92 and 2.57, respectively (Table 1). The higher no. of tubers per plant in both the cases i.e. 20 g and 20 were obtained in the treatments 100% RDF (10.50 and 3.50, respectively) followed by 50% RDF+50% N (FYM) (8.50 and 2.75, respectively).

However, minimum number of tubers/ plant i.e. 6.5 and 2.0 (for >20g and < 20g, respectively) were recorded in 100% N (1/3rd each FYM+NC+CCR) + intercropping with radish. Among the organic sources the number of tubers /plant i.e. 8.25 (>20g) was significantly higher in 100% N (1/3rd each FYM+NC+CCR) + Azospirillum + PSB treatment. However, in small size tuber (<20g), treatments 100% N (1/3rd each FYM+NC+CCR) and 100% N (1/3rd each FYM + NC + CCR + Azospirillum + PSB resulted in equal number of tubers/plant (2.50), although both the treatments were non significant in small size (<20g) tuber. It may be due to the N, P and K with their dynamic availability to the plant. The tuber setting increased rapidly at later stage (60 DAP) after receiving of remaining split dose of nitrogen. In case of treatments, where phosphorus was applied at lower doses (T_5), the initial tuberization was low compared to lower levels of nitrogen application. This is in conformity with the findings of Jaggi *et al.* (1995) who found that application of phosphorus promoted top growth, tuber formation and yield of tuber.

The tuber yield was significantly higher in the treatment 100% RDF followed by 50% RDF +50% N (FYM) and 100% N (1/3rd each FYM + NC + CCR) + Azos. + PSB. The lowest tuber yield was produced with the treatment 100% N (1/3rd each FYM + NC + CCR) + intercropping with radish among all the treatments. The lowest tuber yield was produced with the treatment 100% N (1/3 rd each of FYM + NC + CCR) + intercropping with radish.

The application of 100% RDF produced significantly higher yield compared to all other treatments. This may be due to the quick and timely availability of nutrients through split dose of nitrogen increasing the tuberization resulting in increased production of tubers. The application of 50% RDF + 50% N (FYM) and 100% N (1/3rd

Table 1. Weight and number of tuber/plant and tuber yield as influenced by organic manure, inorganic fertilizer and biofertilizers

		Weight and number of tuber / plant		Tuber yield (q/ha)
		Large (>20g)	Small (>20g)	
T_1	50% RDF + 50% N(FYM)	8.50	2.75	143.63
T_2	100% N (1/3rd each FYM + NC + CCR)	7.25	2.50	131.70
T_3	100% N (1/3rd each FYM +NC + CCR) + intercropping with radish	6.50	2.00	158.08*
T_4	100% N (1/3rd each FYM + NC + CCR) + DSP	7.75	2.25	138.75
T_5	50% N (FYM) + Azos. + RP + DSP	6.75	2.25	121.95
T_6	100% N (1/3rd each FYM + NC + CCR) + Azos. + PSB	8.25	2.50	142.54
T_7	100% RDF	10.50	3.50	156.63
	SEm±	0.73	0.50	0.83
	CD at 5%	2.16	NS	2.56

*Equivalent yield of potato (Tuber yield 119.24 q + radish yield 38.84 q); Azos. : *Azospirillum.*

each FYM + NC + CCR) + Azos. + PSB produced higher tuber yield among the organic sources showing that the tuber yield was also affected by the different combinations of organic and inorganic fertilizers. The application of FYM helped in increasing the content of nitrogen and other essential nutrients, which helped in increasing the leaf area, shoot/plant and dry matter accumulation/plant at the critical stages. The application of FYM helped in initial tuberization and subsequent bulking and resulted in production of large size tuber and higher production. Similar results were reported by Mandal *et al.* (1993) and Sanyal *et al.* (1993). The application of FYM in seed bed for initial stage might have helped in improving the soil physical condition like bulk density, porosity and chemical conditions by releasing the nutrient slowly which had helped in better root development, shoot growth and finally the tuber formation and enlargement. The improvement of all these plant parameter finally contributed in increasing the tuber yield of potato.

Among the organic sources, 100% N (1/3rd each FYM + NC + CCR) + Azos. + NC and CCR along with *Azospirillum* fixed the nitrogen and increased the availability of nitrogen through FYM, neem cake and composed crop residues, as it was associated with crop. The inoculation of biofertilizer in the seeds or its application in the soil increases the nutrient use efficiency from the soil, particularly the efficiency of nitrogen resulting in the higher yield of tuber. Further the PSB increased the availability of soil P by increasing the release of P from the organic resources. Due to this, a sufficient amount of P was made available to plant which increased the number of tubers per hill, tuber N and P content than uptake, dry matter yield and total tuber yield.

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IMPACT OF SUB-SOILING, LAND CONFIGURATION AND ZINC FERTILIZATION ON GROWTH, YIELD AND QUALITY OF CASTOR (*RICINUS COMMUNIS* L.)

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In-situ moisture conservation holds a great promise in stabilizing and stepping up of crop production in drylands, which can be achieved by non-inversion tillage like subsoiling or modified land configuration like broad bed and furrow. Among micronutrients, deficiency of zinc is most common, widespread and frequently found in arid and semi-arid soils. Keeping the above aspects in view, the present experiment was carried out during *kharif* 2003 at Junagadh Agricultural University, Junagadh to ascertain the effect of sub-soiling, land configuration and zinc fertilization on growth, yield and quality of castor (*Ricinus communis* L.)

The experimental soil was clayey in texture having pH 7.9 and EC 0.28 dS m^{-1} with available N 248 kg ha^{-1}, available P_2O_5 33 kg ha^{-1}, available K_2O 280 ha^{-1} and available Zn 0.85 mg kg^{-1}. Field capacity and permanent wilting point were 27.9 and 12.8%, respectively, whereas bulk density was 1.38 Mg m^{-3} with 44.6% porosity. There were 5 main plots assigned to moisture conservation practices *viz.*, M_1- flat bed (FB), M_2- alternate between-row subsoiling (ABRS), M_3- between-row subsoiling (BRS), M_4 - in row subsoiling (IRS) and M_5- broad bed and furrow (BBF) and 3 sub-plots allocated to zinc levels *viz.*, 0, 5 and 10 kg ha^{-1}. The experiment was laid out in split plot design with 4 replications. Subsoiling to a depth of 30 cm was carried out by subsoiler, while a bed of 150 cm width with furrow of 30 cm width and 15 cm depth was formed by BBF former after preparatory tillage and before sowing. The crop was fertilized with 40 kg N and 40 kg P_2O_5 ha^{-1}. Zinc in the form of $ZnSO_4$ was applied at sowing in furrows as per treatments. The castor variety 'GCH 6' was sown at 90 x 30 cm on 20th June, 2003 and harvested according to maturity of different spike orders. The total seasonal rainfall of 1275 mm was received in 42 rainy days. The growth, yield attributes and yield were recorded at harvest. The oil content of seed was determined using Nuclear Magnetic Resonance Spectro Photometer (Model Oxford 4000 NMR analyzer).

Various moisture conservation practices significantly influenced growth, yield and quality characters as well as seed and stalk yields (Table 1). Broad bed and furrow (M_5) recorded significantly the highest values of these parameters, however found statistically equivalent to in-row subsoiling (M_4) in respect of length of main spike, capsules/main spike, spikes/plant, seed weight/plant, seed yield and stalk yield and with in-row subsoiling (M_4) and between-row subsoiling (M_3) in respect of plant height, test weight, shelling and oil content. Conversely, flat bed (M_1) registered the minimum values of these parameters. Broad bed and furrow (M_5) and in-row subsoiling (M_4) increased seed yield to the tune of 20.4 and 17.9% and stalk yield to the extent of 18.2 and 16.1% over flat bed (M_1), respectively. Both these practices might have increased infiltration of rainwater in soil and thereby improved moisture content besides favouring physico-chemical properties of soil. All these might have accelerated growth, yield and quality of the crop. Alike results with BBF were reported by Velayudham *et al.* (1997) in castor and with subsoiling by Nitant and Singh (1995) in pigeonpea.

Application of zinc @ 10 kg ha^{-1} (Z_3) and 5 kg ha^{-1} (Z_2), being statistically at par, significantly excelled plant height, length of main spike, capsules/main spike, seed weight/plant, test weight, shelling, oil content, seed yield and stalk

Table 1. Effect of subsoiling, land configuration and zinc fertilization on growth, yield and quality of castor

Treatments	Plant height (cm)	Inter-nodes	Length of main spike (cm)	Capsules /main spike	Spikes /plant	Seed weight /plant (g)	100-seed weight (g)	Shelling (%)	Oil (%)	Seed yield (q ha^{-1})	Stalk yield (q ha^{-1})
Moisture conservation practices											
M_1-FB	83.67	14.22	35.63	39.43	4.02	34.89	31.62	68.74	46.03	12.70	17.09
M_2- ABRS	89.80	16.57	37.57	44.15	4.87	36.08	31.95	69.51	46.26	13.24	17.85
M_3- BRS	92.35	17.83	39.55	47.82	5.02	37.61	32.59	70.37	46.50	13.61	18.15
M_4- IRS	94.45	18.13	41.28	55.32	5.68	40.91	33.09	74.16	47.12	14.97	19.85
M_5- BBF	99.82	19.50	42.15	60.77	5.77	43.34	33.32	75.05	47.28	15.29	20.20
C.D. (P=0.05)	9.38	1.21	1.55	5.52	0.63	4.84	0.95	4.85	0.85	1.52	1.53
Zinc (kg ha^{-1})											
Z_1-0	85.80	17.09	37.85	45.99	4.97	35.43	32.00	69.74	46.36	12.92	17.40
Z_2-5	94.58	17.11	39.84	50.62	5.05	39.46	32.72	72.44	46.74	14.40	19.19
Z_3-10	95.67	17.55	40.04	51.88	5.19	40.82	32.83	72.52	46.81	14.57	19.31
C.D. (P=0.05)	5.53	NS	0.61	2.13	NS	3.29	0.52	2.50	0.36	0.66	0.63

yield over control (Z_1), while zinc levels could not cause their significance impact on number of internodes and spikes/plant (Table 1). Zinc fertilization @ 10 kg ha^{-1} (Z_3) and 5 kg ha^{-1} (Z_2) increased seed yield by 12.8 and 11.5% and stalk yield by 11.0 and 10.3% over control (Z_1), respectively. By virtue of involvement in various enzyme systems, carbohydrate metabolism and redox processes, zinc might have promoted growth, yield and quality of the crop. Murthy and Muralidharudu (2003) also reported parallel results.

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IDENTIFICATION, CHARACTERIZATION AND EVALUATION OF FOUR WILD SPECIES OF PIGEONPEA AS A STEP TOWARDS INTERSPECIFIC HYBRIDIZATION

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Interspecific hybridization is an attempt to allow transfer of useful genes from related wild species to cultivated types and to understand species affinities based on genetic and chromosomal studies, plant morphology, crossability, meiotic behaviour and seed protein profiles etc. Present study is an attempt to evaluate the potential value of wild species of pigeonpea as one of the parents in interspecific hybridization for utilizing existing genetic variability, identification of known and unknown traits of importance such as resistance to diseases and pests and superior nutritional qualities as preliminary requirement in an interspecific hybridization programme. This study has identified four wild species namely *C. acutifolius, C. goensis, C. mollis* and *C. platycarpus* based on characterization and preliminary evaluation of 13 wild species for some vegetative, floral and fruit characters. Wild species of pigeonpea were obtained from ICRISAT, Patancheru. These four species of pigeonpea flowered and had set pods and seeds at IARI, New Delhi. Some information is already reported in these four wild species (Table 1) (Nene *et al.*, 1990).

Characterization and preliminary evaluation of four wild species and four cultivated types was carried out under screen house conditions during 2001-2003, at IARI, New Delhi, using RBD (randomized block design) as per IBPGR and ICRISAT descriptors (1993). Experiment was conducted in three sets with DOS (date of sowing) as 22 May, 24 July 2001 and 6 June 2002. It was found that four species differ markedly in vegetative characters (growth habit, leaflet shape), fruit (pod form and colour and width, seed shape, presence of strophiole). Significant findings in the present study are given below.

C. acutifolius (F.v. Muell.) van der Maesen had compact and erect growth habit. Leaves were lanceolate with glabrous flower leaf surface. It flowered in 116 ± 0.0 DAS (days after sowing) and reached maturity in 171.3 ± 0.0 DAS Pods were 2 seeded, small, cylindrical, dark purple with grey and square shaped seeds (Table 2).

C. Goeniss Dalz plants were spreading type with ovate to cordate leaves possessing acute tip and glabrous lower leaf surface. Plants flowered

Table 1. Information available in four identified wild species of pigeonpea obtained from ICRISAT, Patancheru

Species name	Identity	Origin	Known details
Cajanus acutifolius	ICPW 002; IBS 2419	Australia	Belongs to secondary gene pool
Cajanus goensis	ICPW 032; JM 3501	India	Belongs to tertiary gene pool
Cajanus mollis	ICPW 052; JM 2943	India	Belongs to tertiary gene pool, maximum seed protein percentage as 33.4%
Cajanus platycarpus	ICPW 064; JM 4350	India	Belongs to teritary gene pool, resistant to *Phyophthora* blight, *Fusarium* wilt, early maturity, high pod set and large seed size

Table 2. **Plant data of four identified wild specices and four cultivaties (cvs) of pigeopea evaluated at IARI, New during 2001-2003**

Plant data	*C. acutifolius*	*C. genensis*	*C. mollis*	*C. platycrpus*	cv.[2] Pusa 9	cv. Pusa 33	cv. Pussa 855	cv. UPAS 120
A. Vegetative	Compact & erect	Spreading	Spreading	Erect/spreading	Erect	Erect	Erect	Erect
Stem colour	Green	Green	Green	Green	Green	Green	Green	Green
Number of branches								
i. Primary	NS[1]	NS	NS	NS	40.0 ± 0.52[3]	39.6 ± 0.40	38.0 ± 0.40	38.1 ± 1.01
ii. Secondary	NS	NS	NS	NS	21.5 ± 2.21	17.9 ± 0.67	17.3 ± 1.75	14.1 ± 0.30
Leasflet shape	Lanceolate	Ovate/cordate	Ovate	Ovate	Lanceolate with acute tip	Broad-elliptic	Elliptic with mucronate tip	Narrow-elliptic
Leaf hairiness	Glabrous	Glabrous	Glabrous	Pubescent	Glabrous	Glabrous	Glabrous	Glabrous
B. Inflorescence and Fruit								
Days to 50% flowering (DAS)	116.0 ± 0.0	115.5 ± 0.0	100.6 ± 9.13	48.0 ± 4.89	140.0 ± 0.50	98.0 ± 0.0	151.0 ± 0.0	147.0 ± 23.06
Days to 75% maturity (DAS)	171.3 ± 0.0	170.2 ± 0.0	172.5 ± 0.0	141.1 ± 19.84	324.0 ± 0.0	315.0 ± 16.97	277.0 ± 14.96	315.3 ± 16.62
Seeds/pod	2	1-2	1-2	2-6	4.0 ± 0.26	4.0 ± 0.10	3.6 ± 0.03	4.0 ± 0.05
Pod colour	Dark Purple /green & purple	Dark purple/ green & purple	Mixed, green and purple	Light beown	Green/purple	Brown/dark brown with purple steaks	Purple/dark purple	Brown with purple steaks
Pod Form	Cylidrical	Flat cylindrical	Flat	Flat	Cylidrical	Cylindricl	Flat/cylidrical	Flat (broad)
C. Seed								
Seed colour pattern	Plain	Plain	Plain	Plain	Plain	Plain/Mottled around seed eye	Plain/Mottled around seed eye	Plain
Base seed colour	Grey	Light grey	Light grey	Dark Purple	White/light brown	Light brown purple	Orange/dark purple	Light brown /grey
Seed eye colour	Medium	Medium	Medium	Wide	Medium	Medium	Medium	Medium
Seed shape	Square	Oval/square	Oval/square	Globular	Square	Globular /elongate	Oval /globular	Oval /globular
Hilum	Absent	Absent	Absent	Present	Absent	Present /Absent	Present in mottled seed	Present
100 seed weight (g)	6.0 ± 0.20	6.8 ± 1.01	6.1 ± 0.11	8.4 ± 0.17	7.8 ± 0.78	8.4 ± 0.06	6.8 ± 0.45	9.1 ± 4.96

1. Not scorable
2. Cultivated variety
3. Data represents mean ± S.D. of 3 replications

in 115.5 ± 0.0 DAS. Pods were 1-2 seeded, small, dark purple to green purple, flat/cylindrical, smooth and reached maturity in 170.2 ± 0.0 DAS. Seeds were light grey, oval to square in shape (Table 2).

C. mollis (Benth) van der Mzesen comb. nov. had spreading growth habit with ovate leaves possessing mucronate tip and glabrous lower leaf surface. Plant flowered in 1006.6 + 9.13 DAS. Pods were 1-2 seeded, small, flat, smooth, green/purple and reached maturity in 172.5 + 0.0 DAS. Seeds were light grey and oval to square in shape (Table 2).

C. platycarpus (Benth.) van der Maesen growth habit was found to be erect/spreading type. Leaves were ovate with acute tip and pubescent lower leaf surface. It flowered in 48.0 ± 4.89 DAS with pods setting in 69-73 DAS. Pods were 2-6 seeded, light green, flat and reached maturity in 141.1 ± 19.84 DAS. Seeds were dark purple, globular shaped with wide seed eye width (Table 2).

Four identified wild species were also tested for resistance to major diseases and insect pest/s. They were found to be highly resistant to *Fusarium* wilt and insect pests like *Helicoverpa armigera* (Hun) (pod borer) and *Melanagromyza* obtusa (Mall) (pod fly) based on open screen house screening using RBD with no plant protection measures. Screening was based on appearance of any *Fusarium* wilt symptoms (Reddy *et al.* 1993) and pod damage characteristic of pod borer and pod fly (Reed and Lateef 1990).

Four cultivated varieties (cvs) Pusa 9, Pusa, 33, Pusa 855, Upas 120 being maintained at IARI, New Delhi, were also evaluated and characteriszed in similar manner as those of wild specied. Variation was observed in number of promary and secondary branches, leaflet shape, pod form, base seed colour, seed shape and number of seeds/pod within cvs (Table 2). Combined susceptibility to insect pests like pod borer and pod fly was found to be more fifty percent (intermediate to high as per descriptors) in four cvs during 2001-2004 based on field screening using RBD with no plant protection measures. Main attention in therefore required to be paid to incorporate these four cvs to improve their insect pest resistance through interspecific hybridization in addition to other desirable traits (Jain *et al.* 2001) based on information generated on known and yet unknown traits in four identified wild species of pigeonpea.

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SUSTAINABLE PRODUCTION OF SCENTED RICE *(ORYZA SATIVA)* WITH MANURES AND BIOFERTILIZERS

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Scented rice with organic tag has huge export potential because of superior quality. In India area under scented rice is increasing due to attractive price and growing demand in market. Production of scented rice using organic manures and biofertilizers is found to favorably alter the availability of several plant nutrients through their impact on chemical and biological properties of soil. With this in view the present study was undertaken to develop manurial schedule for sustainable production of scented rice using manures and biofertilizers as sole source of nutrients.

A field experiment was conducted at Kalai (Aligarh) research station of C.S. Azad University of Agriculture and Technology, Kanpur during rainy (*kharif*) season of 2004 and 2005. The experimental soil was sandy loam in texture having pH 7.5, EC 0.59 ddm^{-1}, organic carbon 0.57% and available P and K 16.01 and 153.39 kg/ha, respectively. The experiment was conducted in randomized block design with four replications consisted of FYM (0.6%N, 0.2%P, and 0.5%K), vermicompost (1.4%N. 1.1%P, and 0.6%K), green manure (*Sesbania esculata*), *Azospirillum*, phosphate solubilizing bacteria (PSB), and blue green algae (BGA) having nine treatments viz. T_1, NPK@ 90 : 40 : 40 : kg/ha; T_2, FYM @ 10 t/ha + *Azospirillum* (Azos) + PSB + BGA; T_3, vermicompost (VC) @ 5t/ha Azos + PSB + BGA ; T_4, GM + BF (A + P + B); T_5, GM + FYM (5 t/ha) + BF (A + P + B); T_6, GM+VC (2.5t/ha) + Azos + PSB + BGA; T_7, GM + FYM (10t/ha) + Azos + PSB; T_8, GM + VC (5t/ha) + Azos+PSB, and T_9, Absolute control (N, o Po Ko). Scented rice cultivar '*Pusa basmati-1*' was transplanted one week after incorporation of green manure (*in situ*)at 20x10 cm spacing in third week of July during both the years. Application of FYM, VC, and green manure were repeated each year during *kharif*. In organic combinations, chemical inputs were not used.

The grain and straw yield of rice during both the seasons of experimentation showed significant variation to different treatments (Table 1). The mean values of two years revealed that maximum grain yield (27.77q/ha) was obtained when rice was grown after green manuring along with bioffertilizers (Azos + PSB + BGA) coupled with FYM (5t/ha) or VC (2.5t/ha) followed by GM + FYM (10t/ha) or VC (5t/ha) + biofertilizers (Azos + PSB), which was at par with the combination of green manure in conjunction with biofertilizers in transplanted rice has also been reported earlier (Singh *et al.*, 2003). Application of NPK through chemical fertilizers recorded higher grain yield (22.96 q/ha) over higher doses of FYM (10t/ha) or VC (5t/ha) applied along with biofertilizers (Azos + PSB + BGA) without green manuring. Reduction in yield may be attributed to slow and inadequate availability of nutriens required at different growth stages. Experimental results clearly indicated that green manuring plays an important role in minimizing yield of rice because of its faster decomposition and mineralization leading to higher availability of plant nutrients. Advantages of green manuring in rice cultivation has also been observed by Chandra and Pareek, (1998), Sriramachandrashekharan and Ravichandran (2004). Straw yield of rice responded similarly.

The economic analysis of various treatments revealed that green manuring along with biofertilizers (Azos + PSB + BGA) coupled with FYM (5t/ha) or vermicompost (2.5t/ha) recorded higher average net return (Rs 1957/ ha) and benefit : cost ratio (2.24) followed by application of biofertilizers (Azos + PSB + BGA) along with green manuring. Though higher doses of FYM (10 t/ha) or VC (5 t/ha) alongwith green manuring and biofertilizers (Azos+PSB) recorded higher yield over NPK application

Table 1. Effect of manurial treatments on yield and economics of scented rice

Treatments	Grain yield (q /ha)			Straw yield (q/ ha)			Economics	
	2004	2005	Mean	2004	2005	Mean	Net return (Rs/ ha)	Benefit : cost ratio (Rs/Re)
T_1	21.65	24.27	22.96	35.02	39.26	37.14	14454	1.99
T_2	19.52	22.10	20.81	31.09	35.40	33.25	10738	1.69
T_3	20.00	23.28	21.64	31.77	37.10	34.44	11782	1.76
T_4	24.38	26.20	25.29	43.26	46.47	44.87	17579	2.20
T_5	26.54	28.22	27.38	48.87	5497	50.42	19059	2.21
T_6	27.14	29.15	28.15	54.07	54.85	52.96	20085	2.27
T_7	25.28	26.12	25.70	43.56	45.01	44.29	15648	1.92
T_8	26.17	27.28	26.73	45.00	46.70	45.85	16946	2.00
T_9	10.12	11.14	10.63	16.50	17.60	17.05	674	1.05
C.D. (P=0.05)	1.84	1.75		3.03	2.99	-	-	-

Average market price of rice grain Rs. 1200/q and straw Rs. 40/q ; Economics is based on mean of 2 years.

through chemical fertilizers but higher benefit : cost ration could not be realized due to higher input cost of FYM and vermicompost. The price of rice was not differentiated (organic/ inorganic) in calculating the economics. Plots fertilized with chemical fertilizers recorded net return of Rs. 14454/ha with benefit : cost ratio of 1.99. Lowest net return (Rs 674 t/h) and benefit : cost ratio (1.05) was recorded with absolute control ($N_0P_0K_0$).

The study revealed that among the various combinations of green manure, FYM or vermicompost and biofertilizers tested, green manure along with /FYM (5 t/ha) or vermicompost (2.5 t/ha) in conjunction with biofertilizers (Azos + PSB + BGA) proved better manurial schedule for yield maximization in scented rice. The results clearly indicated that scented rice may efficiently and profitable be cultivated without using chemical fertilizers with the additional advantage of quality grain besides improvement in soil health as well as balance in agro-ecosystem.

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